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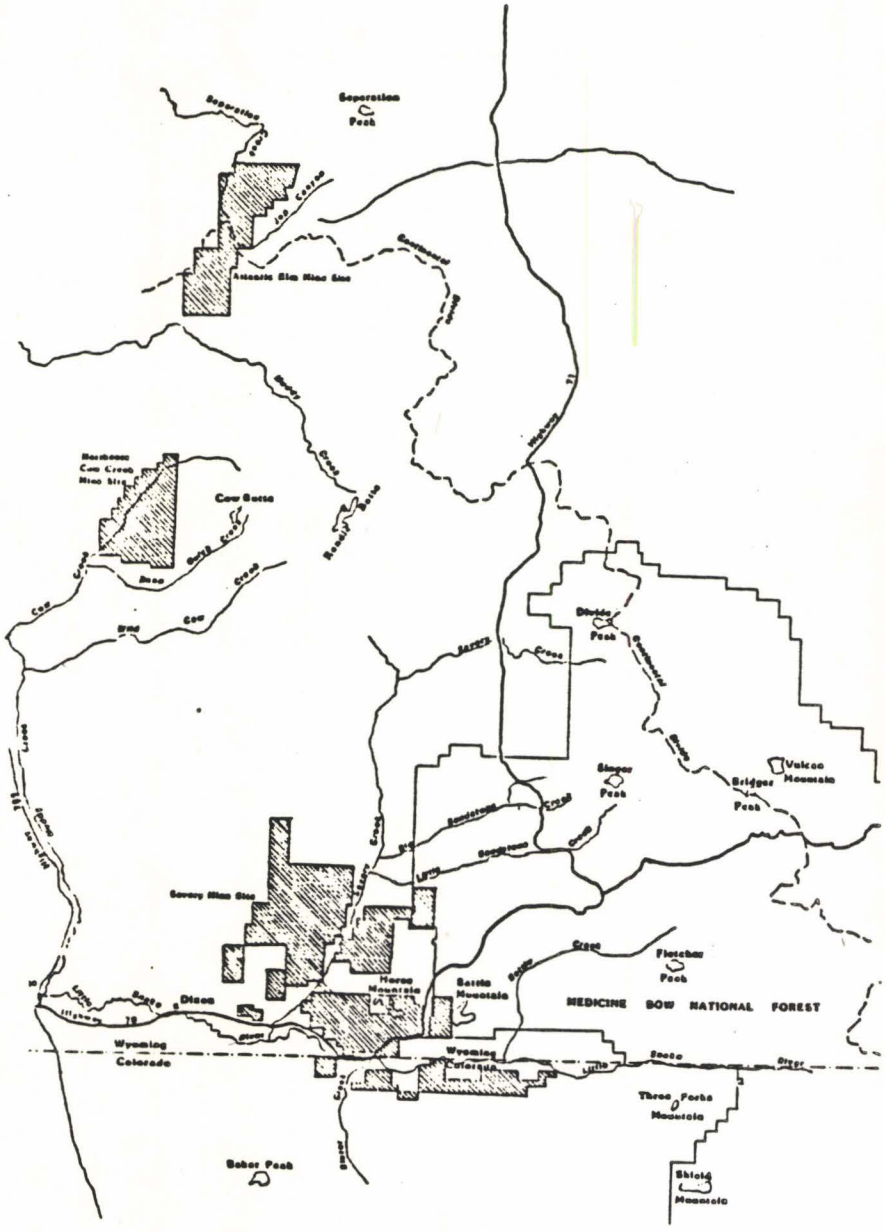
LITTLE SNAKE RIVER KRCRA ELK STUDY

FINAL REPORT



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SEPTEMBER 1985

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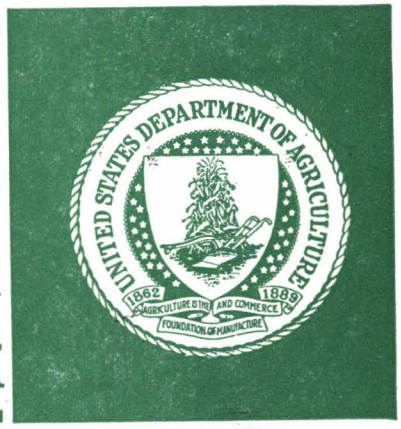

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Project Title: Study of Elk in the Little Snake River Known Recoverable Coal Resource Area (KRCRA) of Southcentral Wyoming

Cooperative Agreements: WY910-1A1-507 Bureau of Land Mangement
RME-81-157-CA Rocky Mountain Energy Company

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ACKNOWLEDGEMENT

The cooperation of many people from the Bureau of Land Management, the Rocky Mountain Energy Company, the Wyoming Game and Fish Department, the Medicine Bow National Forest, and private landowners is greatfully acknowledged.

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INTRODUCTION

The Little Snake River Known Recoverable Coal Resource Area (KRCRA) of southcentral Wyoming is being evaluated for coal leasing by the Bureau of Land Management. The KRCRA is also the major winter range for approximately 2,000 elk. During the summer some of these elk disperse over parts of the winter range, but most of them move to higher elevations on the Medicine Bow and Routt National Forests. These elk are affected by various multiple uses, such as timber harvest, recreation, livestock grazing and energy development. The disturbance and displacement due to mineral exploration and development may exceed the elk's threshold of tolerance.

The Rawlins District of the Bureau of Land Management (BLM) needs data on elk ecology on winter ranges in the KRCRA to evaluate multiple use alternatives. Currently, the BLM is in the inventory and planning stages of determining which Federal lands under its management will be available for coal leasing and mining. Baseline data are needed to evaluate the impacts of coal development on the other resource values of the region, specifically elk. This analysis is required by the National Environmental Policy Act, Federal Land Policy and Management Act, Endangered Species Act, Fish and Wildlife Coordination Act, and BLM Policy regarding multiple use planning and management.

Twenty "Coal Unsuitability Criteria" are applied to each coal area to evaluate conflicts with other resource values under BLM's multiple use management policy. Seven criteria deal directly with wildlife; one of these covers the elk migration corridors and the most critical wildlife winter ranges. Application of criterion requires detailed information to adequately assess the conflicts and impacts. In addition, site-specific information can be used as a basis for recommendations in mine plan design, mitigation, and reclamation should coal development proceed. Primary study emphasis was needed in the Little Snake River KRCRA where the Atlantic Rim, Cow Creek Complex, and Savery Creek Preference Right Lease Application (PRLA) areas. These areas, as shown on the cover, are of high interest for coal development.

The results of the study are of interest to other federal, state, and private land and resource managers as well. The Forest Service has considerable interest in the elk because many of them spend the winter on lower elevation BLM, private, and state lands and migrate to the National Forests during the spring, summer, and fall. Forest managers need information on elk distribution, habitat requirements, and behavior in relation to other forest uses.

The Rocky Mountain Energy Company (RME) owns the mineral rights to some of the large high-quality coal deposits in the Atlantic Rim area of the KRCRA and wishes to develop coal mining on BLM lands along with their own. RME is interested in the elk and habitat changes that could result from coal mining in the area.

The State of Wyoming has rightful ownership of, and responsibility for the wildlife. The Wyoming Game and Fish Department is concerned with elk populations, distribution, and seasonal habitat use on all lands in the herd area. These elk contribute substantially to hunting and other forms of recreation.

Literature Review

Studies on elk behavior in relation to roads, traffic, recreation, and timber harvest have been conducted on the Medicine Bow Range and Pole Mountain area on the Medicine Bow National Forest (Ward et al. 1973, Ward et al. 1976, Ward 1976, Ward and Cupal 1979, and Ward et al. 1980). For a review of the publications on elk ecology, behavior and habitat requirements there are several recent sources including (the new book) "North American Elk Ecology, Behavior, and Management" (Thomas and Toweill 1982) and the proceedings of 2 symposia (Boyce and Haydem-Wing 1979, Peek and Hieb 1976).

Two major elk welfare considerations immediately develop when any land management practices change. First is the concern for the habitat and survival of elk, and second is the effect of human disturbance on elk. Significant changes in the vegetative components of elk habitat come with any resource development or use. Right-of-ways and transportation systems may interrupt well established travel corridors for elk, which can disrupt

their migration and movements during different seasonal and weather conditions. Hunted populations of elk avoid close association with humans; apparently this aversion is related to their experience with hunters. Elk stay about 0.5 mile from people walking on summer and winter ranges where there is an adequate supply of trees for security cover. Elk may be disturbed at greater distances, possibly 2 to 3 miles, on winter ranges where there are no trees. Elk are rarely disturbed by moving vehicles and machinery. They consistently use winter range as cloase as 0.25 mi to Interstate Highways, but are reluctant to cross the highways when traffic is constant.

There are 3 published studies of the impacts of mining and energy development on elk: Kuhn and Martnes (1979) discussed environmental impacts on elk in Alberta and British Columbia. They concluded that better definitions of ecosystem relationships and population dynamics are required.

Johnson found no negative impacts on elk using active coal mine sites in northcentral Colorado. Productivity, calving home range size and fidelity, and habitat utilization patterns of elk using the mine site and elk using control areas were not significantly different. There was no indication that elk abandoned mining areas. Aspen habitats adjacent to active mining continued to be used by elk during the late spring and summer. Elk used reclaimed sites in proportion to their availability during all seasons except late winter when snow depths were prohibitive.

In Idaho, Kuch (1984), Kuch et al. (1985), studied the impact of phosphate mining on elk. He said: "Pellet group data did not suggest that elk or moose used areas within 1/8 mile of the mine substantially less than areas farther away. High variation occurred in the number of pellet groups recorded on the transects. The importance of windswept ridges as winter habitat appeared to outweigh any disturbance factor that might have caused displacement of elk during the winter. Elk used other vegetation types around the Wooley Valley mine less than in the control areas. In the summer months, neither elk nor moose appeared to be displaced from areas adjacent to the mines. These mines have been in operation for over 10 years. A displacement of big game from habitats adjacent to the mines may have initially occurred. Results of this study indicate that displacement may have been temporary or occurred on a local basis only."

"Impacts of human presence and simulated surface mining activities on elk calf movements, habitat selection patterns, and survival were assessed in using a controlled experiment. Compared to undisturbed calves, disturbed calves moved greater distances, used larger areas, showed greater use of the coniferous forest, and lacked selection for physiographic parameters. Cow/calf pairs readily abandoned their traditional calf-rearing area under human and simulated mining disturbance, although no calf abandonment was documented. Winter survival between groups and between years was similar."

"Although sample sizes were small, natural mortality, largely related to winter conditions, was more prevalent among deer (41%) than elk (27%) or moose (14%). Presumed illegal kill or crippling loss accounted for a high proportion of deaths of each species. Presumed illegal kill or crippling loss was highest in moose, 6 of 7 (86%). Illegal kill of mule deer (47%) and elk (55%) was also high. Annual mortality rates for mule deer were 33%/year, 16%/year for elk, and an unexpectedly high rate of 24%/year for moose. These data support a conclusion that illegal harvest is a major problem and a significant indirect impact associated with mine development in southeastern Idaho."

Thomas et al. (1979) suggested a combination of approximately 20 percent hiding cover, 10 percent thermal cover, 10 percent hiding or thermal cover and 60 percent foraging areas as a optimum mix for elk summer range in the Blue Mountains of Oregon and Washington. This concept is new, however, and needs evaluation on other ranges. Their suggested mix has definitely not been the case on winter ranges in Wyoming at the National Elk Refuge in Jackson (Anderson 1958) or on the Medicine Bow Range (Ward et al. 1980).

Because of the lack of information on elk behavior and habitat requirements, studying each potential impact situation separately, before resource use activities begin, is highly recommended. The baseline data obtained on elk populations and distribution can be used for planning and developing mitigation and reclamation procedures before mining begins. Because the potential mining of the KRCRA may be a major impact on elk winter range (with some additional problems with elk summer residents), mitigation and reclamation are critical. Resource managers need baseline data, but the information has not been available.

The study area includes the Hayden District of the Medicine Bow National Forest and adjacent areas on the Routt National Forest in Colorado, and the BLM, state and private lands from the Colorado state line north to Interstate 80 between Rawlins and Creston Junction. The most critical areas are those portions of the winter and summer elk range which coincide with KRCRA's areas, other potential coal mining lands administered by federal, state, and private agencies, and the elk summer range on the National Forests. The study area encompasses the Wyoming Game and Fish Department's elk hunting areas 13 (Big Creek), 14 (Hog Park), 15 (Spring Creek), 21 (Baggs), and 108 (South Rawlins).

The Rocky Mountain Energy Company has a vested interest in the Atlantic Rim area. Other areas being considered for coal, gas, and oil development are the Cow Creek tract in the northeast and Savery Creek in the south of the KRCRA. Site-specific analysis and tract reports for each of these areas have been prepared by the BLM and are available at the Rawlins District Office. These documents present maps and summaries of the energy resource areas, including mining assumptions and environmental impacts.

Elevations range from 6,500 feet at Slater, Colorado, to 11,422 feet on Davis Peak in Colorado and 11,004 feet on Bridger Peak along the Continental Divide in Wyoming. The topography varies from stream bottoms and sagebrush flats at the lower elevations, rolling hills and ridges at intermediate elevations, and steep mountainous terrain at the higher elevations. The valleys and foothills on the south end of the study area slope to the west and south, giving them a high degree of exposure to the winter sun. The topography at the north end of the KRCRA consists of hogback ridges and small drainages with various orientations to compass direction.

The geology of the study area is described in 3 theses from the University of Wyoming (Ritzma 1949, McDavid 1953, Good 1960). The majority of the area is a broad terrace composed of a Brown's Park formation of Miocene-age sandstones overlying a basement of cretaceous rock. There are six soil groups present in the area according to Dunneweld's (1957) classification. Parent materials of the soils are shale, sandstones, or alluvial deposits derived from shale and sandstone, or a mixture of these. The granite mountains of Battle, Sheep, Squaw, Beaver, Shield, Columbus, and Baker (to name a few) are apparently a result of ancient volcano activity.

Drainage patterns consist of many short steep draws which form into longer, more meandering drainages, which in turn form the major drainages of the Little Snake River: Battle Creek, Savery Creek, and Muddy Creek. Separation Creek from Atlantic Rim drains into the Great Divide Basin. Battle and Savery Creeks are permanent while Muddy and Separation Creeks are intermittant. Drainages on the east side of the Continental Divide drain into the North Platte River with the Encampment River and Big Creek being the main streams. Good quality surface water is available throughout most of the area, most of the year.

Approximately 3,000 elk, including new calves, use the study area during the summer. Hunter harvest was calculated to be 896 for 1979, 1,161 for 1980, 852 for 1981, 703 for 1982, 545 for 1983, and 615 for 1984. The herd is very healthy and has increased from an estimated 1,500 in the spring of 1974 (Compton 1974) to its present number. Elk wintering distribution has expanded from the concentration areas at Battle and Horse Mountains and along Savery Creek to further north in the Cow Creek Complex, Atlantic Rim, and Miller Hill areas. The elk on the east side of the Continental Divide along Independence Ridge have also increased.

The climate throughout most of the study area is semi-arid with extreme diurnal, seasonal, annual, and local variability. Until recently there was no climatological data available that could be applied to the entire area. Long term data is available from the weather station at Dixon (elevation 6,479 feet) and the Forest Service has 17 years of weather data from the Stratton Study area about 15 miles west of Saratoga (elevation 7,910 feet). Temperatures range from record highs of nearly 100° F in the western portion to record lows of -50° F in the mountains. The area at 7,300 feet elevation receives about 19.7 inches of precipitation annually; two-thirds of the total falls as snow. Summer precipitation for the period June 1 to September 30 averages 5.7 inches (Sturges 1977). The higher elevations receive much more moisture (40 inches or more) then the lower elevations. The summers are short, averaging about 80 days frost-free with cool nights and warm days. The winters could be classified as moderate to severe and are usually long and cold. The 30-year average low temperature at Dixon from December to March was -21° F. Snow cover at higher elevations (above 9,000 feet) in October or November drives the elk lower, where

they concentrate on their winter range. Snow can be found on north facing slopes and in heavy conifer timber as late as mid-July, but the southern exposures may become bare in early April. Snow depths and distribution are much more variable on the winter ranges depending on depths, temperatures, exposure, and wind.

Under Kuchler's (1964) classification of potential climax types, most of the area in the KRCRA would be classified as the sagebrush-steppe (Artemisia spp./Agropyron spp.) with lesser areas of juniper-pine (Juniperus spp. and Pinus spp.). The higher mountains to the east are a western spruce-fir forest (Picea spp. and Abies spp.) climax while the foothill areas are a mountain mahogany-oak shrub (Cerocarpus spp. and Quercus spp.) climax type. Kuchler's classification indicates that most of the pine and quaking aspen in the western Sierra Madres are on previously burned-over sites. The BLM Rawlins District office and the Medicine Bow National Forest identifies the following vegetation types in the study area: aspen riparian woodland, sagebrush-mixed grass steppe, mountain shrubland, juniper woodland, quaking aspen woodland, aspen conifer woodland, lodgepole pine, engelmann spruce-subalpine fir and alpine. The BLM and Forest Service classifications are used in this report.

Objectives

The primary objective of this study was to provide land and resource managers with accurate data and analysis of elk habitat requirements and migration corridors within the Little Snake River KRCRA, with special emphasis on the energy resources of Atlantic Rim, Cow Creek Complex, and Savery Creek PRLA areas.

Detailed information on elk ranges and migration corridors is needed in order to apply coal unsuitability criteria number 15 (state resident fish and wildlife of high interest) to the coal areas. This criteria states:

"Federal lands which the surface management agency and the state jointly agree are fish and wildlife habitat for resident species of high interest to the state and which are essential for maintaining these priority wildlife species shall be considered unsuitable. Examples of such lands which serve a critical function for the species involved include:

(a) Winter ranges most critical for deer, antelope, and elk.

(b) Migration corridors for elk.

A lease may be issued if, after consultation with the state, the surface management agency determines that all or certain stipulated methods of coal mining will not have a significant long-term impact on the species being protected. Exceptions are that this criterion does not apply to lands: to which the operator made substantial legal and financial commitments prior to January 4, 1977; on which surface surface coal mining operations were being conducted on August 3, 1977; or which include operations on which a permit has been issued."

The results of the study will give land and resource managers the information needed to accurately assess the multiple use conflicts and long-term impacts associated with coal or other energy development in the area. The study will also give natural resource managers the information needed to assess the effects on elk of forest uses and help determine the proper elk management to keep their numbers in harmony with the habitat's carrying capacity.

Specific objectives were:

1. Determine the boundaries of elk winter range within the Little Snake River KRCRA and delineate the crucial areas and the numbers of elk associated with each area.
2. Determine elk habitat use patterns within the winter range under various snow cover conditions.
3. Determine vegetation availability, production, and composition on elk feeding sites on both winter and summer ranges in relation to elk use.
4. Determine elk behavior in relation to hiding and thermal cover requirements.
5. Identify elk migration routes.
6. Evaluate competition and interaction between elk and other ungulates within the area.
7. Evaluate elk behavior in relation to human disturbances on both winter and summer range.
8. Develop recommendations for mitigation and reclamation standards to be used if coal development proceeds.

METHODS

Elk movement and habitat use were determined with the aid of telemetry on both aerial and ground surveys. Telemetered elk and their associates were located and counted throughout the year. More elk counts and accurate sex and age data were possible on winter ranges because of the concentration of elk in a smaller area and the lack of tree cover on the KRCRA. Aerial photos, taken with a 35 mm reflex camera and fine grain color film, were used to record the location and number of elk in large groups in relation to habitat and animal activity.

Radio telemetry has been used extensively the past 15 years to determine the location and activities of elk without disturbing them (Ward et al. 1973, Ward 1976, Craighead et al. 1973, Ward and Cupal 1979, Marcum 1976). The elk can be located from an airplane in remote or inaccessable areas in a short period of time with telemetry. Activity patterns, home ranges, habitat use, behavior in relation to human disturbances, and elk travel routes can be reliably defined. Transmitters and receiving and monitoring equipment that will operate for up to 4 years are commercially available. With telemetry a few trained people can accurately monitor the elk.

Elk Capture Techniques

Elk were captured by trapping or tranquilizing. Traps were either corral or small Clover traps which were baited with grass hay. No trapped elk were drugged. Two cows (No. 12 & 15) were immobilized with succostrin shot from a capture gun in a helicopter. Both of these cows were in the Miller Hill and Cow Butte area on the north end of the KRCRA. All the other 43 telemetered elk from the north end of the KRCRA were trapped in Clover traps scattered from Atlantic Rim to Deep Gulch Ridge.

The 33 radio collared elk were trapped in either the large corral trap or the 2 Clover traps at the Horse Mountain area on the south end of the KRCRA. Another 14 elk at the corral trap received numbered PVC tubing neck collars. Since these numbered collared elk furnished so little data they were not considered in the results.

Clover traps were used to trap 14 elk on the east side of Independence Ridge near Big Creek. Eight received telemetry collars, the other 6 were collared with PVC tubing. Only data from the telemetered elk and their associates are included in this report.

Field data on elk either seen or located by radio telemetry included: observer; date; time; weather and snow conditions; elk location; elk seen; activity; relation to slope; aspect and cover; elk in relation to cattle, horses, domestic sheep, mule deer, and antelope; elk in relation to multiple uses such as mining and exploration, timber management, roads, traffic, and recreation; and habitat type. The information was later entered into a computer and summarized by season and major winter range location.

Seasons were defined as spring (April to June), summer (July to August), fall (September to November), and winter (December to March). The calving season was considered May 20 to June 10. Some calves undoubtedly were born before or after these dates, but the majority of the calving took place during this time. The 20 days were used to better define calving use areas because of elk movement both before and after these dates. The fall breeding season was not separated from the rest of the fall season because of the elk distribution and movements associated with hunting seasons.

Three general winter range areas were identified within the study area, 2 on the west side of the Continental Divide and 1 on the east. The KRCRA was divided into north and south ends. The winter range units were quite distinct although a few elk changed units from one year to the next. The dividing line between the 2 areas on the KRCRA was marked by the deeper snow accummulation on the open rolling hills in the Brown's Hill area which is between Loco Creek on the South and Cherokee Creek on the north. The Continental Divide separated the KRCRA on the west from the winter range in the Encampment River and Big Creek areas on the east. However, elk from these 3 winter ranges showed mixing and overlap on the late spring, summer, and fall ranges.

The elk wintering on the north end of the KRCRA are divided into either resident or migratory herd categories. The distinction is not definite, however, because some of the elk migrated only in some years. These elk herds were divided mainly because of the extreme difference in the habitats used during the late spring, summer, and fall. The resident elk have only deciduous trees (mainly aspen) for thermal and hiding cover

whereas the migratory elk use both aspen and the coniferous forest at high elevations. Some of the resident elk were seen using the proposed coal mining area on Atlantic Rim in all seasons.

Aerial Surveys and Tracking Flights

Fixed wing aircraft were used to record telemetered elk data and elk sightings at least once a week throughout the study and more often during the winters when weather conditions permitted. The north end of the KRCRA was flown every flight because of the resident elk in the area. For safety, the survey flights were made at higher elevations during windy weather. At least 2 observers were on board each flight. One person watched the area on each side of the airplane and coordinated the operation of telemetry equipment to take fixes and record data. Maps, notes, and a tape recorder were used during the flights, and the information was transferred to data sheets immediately after landing.

Helicopter flights in a 3-place Heller aircraft were made twice each year to census and classify elk on the KRCRA winter range. The principle investigator and a biologist from the Wyoming Game and Fish Department made the counts during good weather with calm winds. The entire area was flown and numbers of elk and their specific location and activity were recorded.

The Wyoming Game and Fish Department biologist made census flights in a super-cub airplane within a few days of 2 of the helicopter flights. The counts from these flights were not consistent with the helicopter counts. The helicopter's slow speed, low altitude, and ability to fly up and down slopes were useful in getting better data. Also, the elk tended to move when the helicopter approached them at slow speeds, making them easier to see.

Ground trips were made all year to known elk use areas to count and classify as many elk as possible. Notes were also taken on human activities and elk habitat conditions that were difficult to determine from the airplane. The elk on the north end of the KRCRA were in such open terrain that they were hard to approach from the ground without disturbing them. The only trees for hiding cover were the aspen, which filled with deep

snow in winter. Elk used the topographic land features as hiding cover in absence of tree cover to keep away from people.

Aerial and ground photographs were taken of elk to identify and document use areas and aid in counts. Fine grain color film was used in a hand-held 35mm reflex camera. Slides were labeled as to time, place, habitat, and elk numbers and activity after viewing either through a projector or under a binocular microscope.

A special 35 mm camera system was developed for taking aerial photographs from 14,000 feet to record snow distribution. The system consisted of a commercially available 35 mm motor driven camera with 35 mm lens and film pack that held 250 frames and could be exposed 1 frame at a time by infrared remote control. An aluminum box that could be mounted on either the foot step or wing strut of the airplane held the camera. Sample strips approximately 1 mile wide were photographed of known prime elk use areas when snow conditions warranted. The film was either read through a video scanner or black and white prints were made to identify snow accummulation and bare ground areas. The video scanner was used to measure percentages of bare ground and light covered snow areas.

Vegetation Measurement

Vegetation production and composition were measured at elk use sites on the KRCRA by plant ground-cover estimates as described by Daubenmire (1959) and individual clipped plant dry weights from the same plots. At each site, 5 random points were selected at least 50 meters apart. At each point a 30 meter tape was stretched towards north. Two random points on the tape were selected and marked on the ground with plastic orange stakes for reference in future years. From each stake, a transect was located in an easterly direction and marked with a stake at 30 meters. Each transect had 30 plot locations at meter intervals for a total of 60 points. Five points out of the 60 were randomly selected from a random-numbers table for use in selecting plots to be measured each year. Plot numbers were used only once. Each plot measured 50 cm by 20 cm along the transect line on the north side.

The plant ground-cover estimates were made, then each plant species was clipped at ground level, placed in a paper bag and labeled as to species, plot number, location, date, and technician. Plant names were taken from Beetle (1970).

Plant samples were oven dried and weighed. The totals for each species, for each transect, and within each elk use area were summarized. The average weight and standard deviation for each species per unit of land area for each elk use site was then calculated.

A cluster analysis was conducted to determine the similarity and differences between elk use sites. Plant cover estimates were compared with the clipped weight methods of measurements with regression and correlation analysis.

Telemetry was used to track elk to their thermal cover use areas during warm weather where they were usually found resting and ruminating during the day. To determine elk hiding cover sites these same elk were disturbed by walking people and then followed to the elk's choice of hiding cover. In some cases it was hard to pin-point the exact locations of hiding cover because the elk stayed in similar habitat and did not have a long flight distance. When this happened, the site where the elk made their first stop after the initial harassment was chosen to represent hiding cover.

Elk bed sites were located and, if possible, the number of elk using the site was determined. Rarely were all the elk seen, but the number of beds could be determined by elk imprints in the duff. An average of 14 elk were seen at 26 sites.

At each of the sites a 7 acre plot was set up with the elk bed in the center. Each site was located on a topographic quadrangle map and the legal description, aspect, slope, elevation and major tree species were recorded. At each site 5 transect lines 98.4 ft long and 32.8 to 65.6 ft apart were randomly located and oriented in an east to west direction to facilitate taking photographs.

At the starting point of each transect line, crown cover was estimated and photographed with 35 mm color film and a 55 mm lens, aimed straight up. The 2 or 3 people doing the field work estimated the canopy cover at each location and recorded the consensus figure. In the laboratory, the color negatives were projected on a 9 in. viewing screen and a dot grid used to

measure canopy cover. The same slides were also measured on a video scanner to determine the percent of the field of view covered with vegetation. The photograph method was similar to that described by Clark (1961) and Bergen (1974).

The basal area of trees was measured using a 10X wedge prism (Bitterlich 1961) at 32.8 ft intervals along each of the 5 transect lines for a total of 20 plots per site. The average basal area was calculated for each site and presented in square-feet per acre.

Stems per acre and the average diameter breast height (DBH) of trees over 3 feet tall were measured on 9.8 x 9.8 ft plots located at the 65.6 ft interval along each of the 5 transect lines. Trees were counted according to DBH and species. Trees less than 1 inch in DBH were grouped together while all others were measured individually. Average DBH and stems per acre were calculated for each site.

Sight distances were measured in each plot using a portable cover board (Wight 1983). The 1 x 8 ft board was held perpendicular to the ground on the long axis. The board was set at the 33, 66, and 98 ft marks along each of the 5 transect lines. An observer estimated the percent of the board visible and took a 35 mm color photograph with a 55 mm lens at each interval. A chalkboard was used in each photo to identify site number, date, and distance. The estimate percentages of the board visible were averaged for the 33, 66, and 98 ft intervals at each plot.

Elk thermal cover characteristics were similarly measured during August of each year on 42 elk use sites scattered over summer range in southcentral Wyoming. Elk also used 12 of these sites for hiding cover.

RESULTS

Climate

The Stratton Sagebrush hydrology study located at UTM 4588.6N 320.0E NW1/4SE1/4 Sec.23 T17N,R87W, north of Divide Peak near the Continental Divide at 7,910 feet elevation, has maintained instruments that recorded the temperature, wind and precipitation for the past 17 years. Because this site is near the Continental Divide, it receives the most wind and precipitation in the study area. Snow accumulation records are not obtained every year, but the daily precipitation records at Twin Groves, UTM 4580.9 N 319.1 E, SW1/4, NE1/4 Sec. 15 T16N, R87W, elevation 8,080 ft, are available. The following amounts of moisture have been received during the period of the elk study:

Precipitation in inches

Month	1980	1981	1982	1983	1984	1985
January	4.35	0.59	2.29	0.74	0.88	1.22
February	1.76	0.62	0.90	1.06	1.61	1.27
March	2.22	2.18	2.44	2.85	3.14	2.20
April	0.86	1.59	1.50	2.39	3.37	1.47
May	2.85	4.90	1.48	2.58	1.26	1.34
June	0.02	0.52	0.52	1.73	1.47	1.15
July	0.77	1.45	1.38	1.55	4.45	
August	1.50	0.69	0.88	1.41	1.20	
September	1.17	0.74	3.00	1.00	1.84	
October	2.32	3.67	1.95	2.07	1.52	
November	0.77	1.01	1.88	4.77	1.51	
December	0.55	2.84	1.51	2.79	2.33	
TOTAL	19.14	20.80	19.73	24.94	24.58	

Snow measurements were made from 1983 to 1985 on permanent transects established at Atlantic Rim, Cow Butte, and Horse Mountain. Aluminum rods were used to measure depth; snow density was measured using the standard Mount Rose (Federal) sampler. At each site, 10 stations spaced 10 paces

apart along a transect running perpendicular to the slope were sampled for density. Five snow-depth measurements were made at each station.

Transects were located on 60 to 100 percent slopes facing north and south and on level ground. The different aspects and slopes are used to record the different amounts of snow accumulation relative to solar radiation. Solar radiation at 40° latitude reaches its highest value (584 to 724 cal/cm^2/day) on 60-degree (133 percent) south facing slopes during December, January, and February, while at the same time 45-degree (100 percent) north-facing slopes receive no direct solar radiation (Buffo et al. 1972).

Wind speed and ambient air temperature at the BLM weather stations on Atlantic Rim on the north end and on Horse Mountain on the south end of the KRCRA were averaged for 3 short periods during December 1984 and January and February 1985 using data provided by the BLM weather monitoring stations. The automated instruments recorded hourly wind speed and temperature. The results were as follows:

		Wind Speed (mph)			Temperature F°		
Location	Period	Avg.	Min.	Max.	Avg.	Min.	Max.
Atlantic Rim	Dec. 17 to 20	22.5	10.1	33.4	20.6	7.6	38.7
	Jan. 2 to 10	13.3	1.5	33.3	20.6	3.7	32.6
	Feb. 5 to 8	28.3	11.3	51.6	8.7	-11.2	26.2
Horse Mountain	Dec. 17 to 20	8.8	2.1	26.3	26.6	9.7	37.1
	Jan. 2 to 10	4.9	1.8	10.8	21.5	- 6.0	45.2
	Feb. 5 to 8	9.2	2.4	22.8	15.3	-18.9	37.5

The wind is considerably stronger on Atlantic Rim where the anemometer is 764 feet higher in elevation and located on an exposed west facing slope. The wind blows almost constantly on Atlantic Rim, which results in wind blown ridges and large snow drifts. The calmer wind on Horse Mountain on the south end of the KRCRA does not move the snow, consequently wind blown ridges and snow drifts are not common.

Air temperatures at the ends of the KRCRA average within 7 degrees F of each other. The extreme low and high temperatures are greater on the south end, but the wind-chill factor on the north end would cause an equal or greater amount of discomfort for the elk. Temperatures and wind at the Stratton Study area were within the range recorded by these two BLM weather stations, but the wind speed at Stratton is more similar to the wind recorded at Atlantic Rim.

Snow measurements were made either by aerial photos or probes or both on the KRCRA elk use areas each winter. The low precipitation received during the November to mid-March period of 1980-81 resulted in very light snow accumulations and the elk distribution reflected the lack of snow. Many migratory elk stayed near the coniferous forested areas and never showed up on the winter ranges on the KRCRA. Even the aspen stands where there is usually 4 to 6 feet of snow had only about a foot of snow; elk were frequently seen resting and ruminating in these stands. Snow measurements for the winters of 1982-83, 1983-84, and 1984-1985 are presented in Table 1. There is a definite difference in snow accumulation and distribution patterns between the north and south end of the KRCRA elk winter range. Both the snow measurements and aerial photographs show that Atlantic Rim receives the least amount of snow and the greatest amount of snowdrifts. This weather pattern results in more wind-swept ridges and south facing slopes with extensive areas of little or no snow. This phenomenon shows on the LANDSAT photographs taken March 26, 1973 and February 26, 1975, under clear weather conditions and heavy snow cover.

Three pen thermographs were used to record ambient and ground temperatures on the elk winter range on the west side of Battle Mountain during the winter of 1984-85. Average weekly maximum temperatures (C°) on flat ground, a 40% south facing slope, and a 40% north facing slope at 39 inches (1 m) above ground, at ground level, and 6 inches (15 cm) below ground are shown in Figure 1. Temperature fluctuations above the ground were similar at all three sites with warmer readings on the south facing slope early in the winter. The ground surface temperatures were below freezing on the north and south facing slopes and just above freezing on the flat site, until early March when the south facing slope began warming up and the snow melted off. The south facing slope stayed bare except immediately after snowstorms. The flat site stayed covered with snow until

Table 1. Snow measurements on the KRCRA elk winter range.

	Dates	Level ground		North slope		South slope	
		Depth in.	Density%	Depth in.	Density%	Depth in.	Density%
Horse Mountain	12/09/82	10.0	22	17.9	21	11.3	25
	12/11/83	11.1	29	21.0	26	14.6	no data
	01/11/83	11.0	21	18.2	12	10.3	25
	12/29/83	28.6	20	37.8	19	31.5	38
	12/21/84	16.3	no data	23.4	no data	16.6	no data
	01/31/83	17.2	no data	28.3	no data	11.0	no data
	02/07/84	28.0	24	37.3	24	26.4	26
	01/29/85	24.3	18	30.8	18	18.5	19
	02/24/83	22.8	25	29.3	25	9.7	32
	03/01/84	33.0	no data	43.6	no data	27.0	no data
	02/28/85	23.2	24	29.3	21	13.0	28
	03/17/83	17.8	37	24.1	31	0.6	no data
	03/14/84	30.4	30	42.1	34	24.1	33
	03/18/85	19.0	no data	27.5	no data	0.2	no data
	04/05/84	29.9	33	41.9	26	16.0	32
	04/30/85	14.0	33	24.3	29	0.0	no data
Cow Butte	01/30/85	19.5	22	34.8	22	8.9	20
	02/25/83	13.4	26	no data			
	03/01/84	25.3	no data	48.4	no data	7.9	no data
	02/27/85	16.2	26	40.0	24	3.0	no data
	03/10/83	8.9	no data			6.3	no data
	03/17/83	5.5	33				
	04/06/84	24.5	27	51.1	32	20.4	43
	04/02/85	10.1	25	42.3	22	8.2	no data

Table 1. Snow measurements on the KRCRA elk winter range. (Continued)

	Dates	Level ground		North slope		South slope	
		Depth in.	Density%	Depth in.	Density%	Depth in.	Density%
Atlantic	01/06/83					2.2	no data
	02/17/83					2.5	no data
	01/30/84	15.3	no data	31.8	no data	3.8	no data
	01/30/85	9.9	16	28.4	20	2.2	no data
	03/02/84	23.0	no data	37.1	no data	3.0	no data
	02/27/85	9.7	26	31.7	23	1.1	no data
	04/05/84	18.1	28	42.0	24	2.3	38
	04/02/85	0.4	no data	33.7	25	0	no data

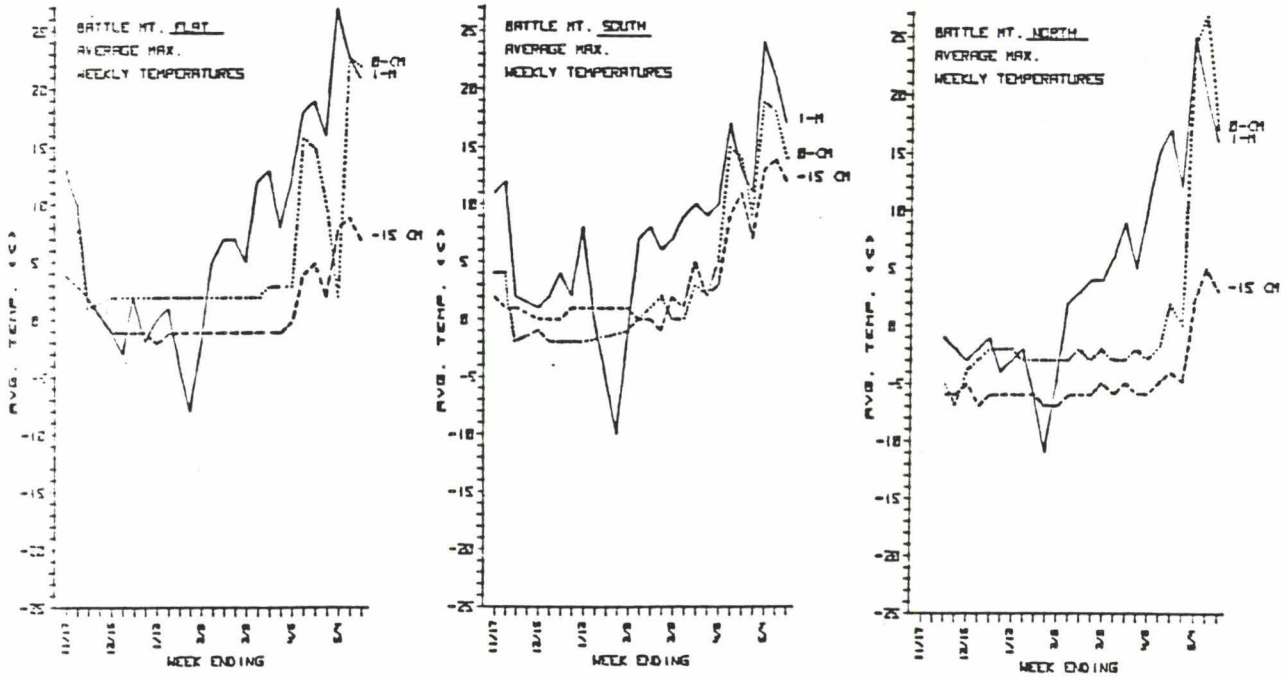

Figure 1. Average weekly maximum temperatures (C^{o}) during the winter of 1984-85 on three aspects (flat, south, north) and (1-m) above ground, (0-cm) surface and (-15 cm) below ground at Battle Mountain.

late March, and the temperature rose after the snow melted off. Subsurface soil temperatures rose within a day after snow melt, particularly on the slopes. The flat site was more erratic due to water flow. The north facing slope soil temperatures were almost a month later in warming to above freezing temperatures. Plant development responds to the warmer soils on the south exposures. The elk also take advantage of the early plant development for food and a place to warm on very cold days.

History of Telemetered Elk

There were 86 telemetry collars installed on elk during the study. All the elk were captured during the winter (Table 2). The following tabulation is the number of elk collared each year:

Winter	Males	Females	Total
1981	3	6	9
1981-82	4	13	17
1982-83	4	17	21
1983-84	6	18	24
1984-85	3	12	15
Totals	20	66	86

Only 9 elk were captured in early 1981 due to the late start of the study and a very mild snow year that made trapping difficult. The low number of bulls in the sample is a reflection of the population. Eight male calves, 4 spikes, and 8 branch antlered bulls were fitted with telemetry collars. Five of the branch antlered bulls were trapped at Big Creek on the east side of the Independence Ridge. One male calf, 3 spikes, and 1 branch antlered bull were trapped at Horse Mountain on the south end of the KRCRA. Seven male calves, 1 spike, and 2 branch antlered bulls were trapped on the north end of the KRCRA. Three of the 6 calves were trapped on Atlantic Rim.

There were 14 female calves and 52 cows fitted with telemetry collars. Three cows were trapped on the east side of Independence Ridge near Big Creek. Four female calves and 24 cows were trapped at Horse Mountain on the south end of the KRCRA. Ten female calves and 25 cows were captured on

Table 2. Elk Telemetery Capture Record on the Little Snake River Known Recoverable Coal Resource Area and Independence Ridge.

Collar No.	Frequency	Installation Date	Sex	Age	Ear Tags	Location	Date Off	Reason	Location
1	172.2375	02/01/81	M	Calf	none	Atlantic Rim	04/22/81	Off Elk	McCarty Canyon
2	172.2688	03/20/84	F	Ad	B082-B083	Big Creek	10/19/84	Harvested	East Big Creek Lake
3	172.2675	02/12/81	F	Ad	G1104	Atlantic Rim	10/20/81	Harvested	Atlantic Rim
4	172.3090	05/08/81	F	Ad	G1108	Divide Peak	10/23/81	Harvested	McCarty Canyon
5	172.3625	04/16/81	M	Calf	none	Divide Peak	10/27/82	Shot	Independence Ridge Colo.
6	172.2812	12/15/82	M	Calf	none	Horse Mountain	04/12/84	Winterkill	Little Snake River
7	172.2313	05/15/81	F	Ad	none	Divide Peak	10/26/82	Harvested	Atlantic Rim
8	172.2888	03/21/84	F	Ad	B087-B088	Big Creek			
9	172.2814	01/09/82	F	Ad	none	Horse Mountain	10/18/82	Harvested	Three Forks Peak Colo.
10	172.2885	12/10/82	F	Ad	none	Horse Mountain	05/22/84	Off the Air	N. Fk. Encampment River
11	172.2375	01/09/82	F	Ad	H420-H429	Horse Mountain	03/28/84	Winterkill	Pothook Feedline (10 yrs)
12	172.2690	04/09/81	F	Ad	none	Miller Hill	10/31/83	Shot	Atlantic Rim
13	172.2875	05/05/81	F	Ad	none	Divide Peak	11/07/81	Harvested	McCarty Canyon
14	172.3175	01/20/82	F	Calf	none	Atlantic Rim	11/15/82	Harvested	High Jack Creek
15	172.3636	02/18/82	F	Ad	none	Cow butte	10/29/84	Shot	Rendle butte
16	172.3875	05/11/81	M	Bull	none	Divide Peak	10/18/82	Harvested	Ridge N. of Roaring Fk.
17	172.2344	01/22/82	F	Ad	none	Atlantic Rim	02/20/82	BrokentNeck	Atlantic Rim

Table. 2. Elk Telemetry Capture Record on the Little Sname River Known Recoverable Coal Resource Area and Independence Ridge. (Cont.)

Collar No.	Frequency	Installation Date	Sex	Age	Ear Tags	Location	Date Off	Reason	Location
18	172.2605	01/09/82	M	Spike	none	Horse Mountain	10/15/82	Harvested	Elkhorn Mtn. Colo.
19	172.2956	01/20/82	F	Ad	none	Atlantic Rim	10/30/82	Shot	West side Miller Hill
20	172.3105	02/23/82	F	Ad	none	Horse Mountain	09/27/82	Off the Air	Mill Cr. Little Sandstone
21	172.3605	01/22/82	M	Spike	G1178-G1179	Horse Mountain	10/16/82	Harvested	Battle Cr. Forks
22	172.3848	01/22/82	F	Ad	G1176-G1177	Horse Mountain			
23	172.2395	12/06/82	F	Ad	G1303	Horse Mountain	06/08/83	Off Elk	South side Battle Mtn.
24	172.2656	12/10/82	F	Ad	none	Horse Mountain	04/26/84	Winterkill	Chalk Bluffs, Colo.
25	172.2840	04/10/82	F	Calf	none	Deep Gulch Ridge	10/30/82	Harvested	Cow Creek
26	172.3198	12/16/82	F	Ad	G1301	Horse Mountain			
27	172.3703	03/22/82	F	Ad	none	Horse Mountain	04/26/84	Winterkill	Chalk Bluffs, Colo.
28	172.3955	03/22/82	M	Calf	none	Deep Gulch Ridge	10/18/82	Harvested	Hells Canyon, Green Ridge
29	172.2447	01/20/82	M	Calf	none	Atlantic Rim	10/18/82	Harvested	Atlantic Rim
30	172.3966	12/16/82	M	Spike	G1302	Horse Mountain	10/22/83	Harvested	Battle Mountain
31	172.2375	05/05/81	F	Calf	G1105-G1106	Divide Peak	07/15/85	Off the Air	N. Fork Spring Creek
32	172.2625	03/09/82	F	Ad	none	Horse Mountain			
33	172.2875	12/15/82	F	Ad	none	Cow Butte	10/18/82	Harvested	Hagerty Creek
34	172.3125	03/09/82	F	Ad	none	Deep Gulch Ridge	10/26/82	Harvested	Jack Creek
35	172.3630	12/10/82	F	Ad	none	Horse Mountain			

Table 2. Elk Telemetery Capture Record on the Little Snake River Known Recoverable Coal Resource Area and Independence Ridge. (Cont.)

Collar No.	Frequency	Installation Date	Sex	Age	Ear Tags	Location	Date Off	Reason	Location
36	172.3892	01/05/83	F	Calf	G1315-G1316	Deep Gulch Ridge	11/19/83	Off the Air	Fletcher Peak
37	172.2395	01/16/83	M	Calf	none	Atlantic Rim	10/16/83	Harvested	Singer Peak
38	172.3175	12/07/82	M	Spike	none	Deep Gulch Ridge	10/26/83	Harvested	Jack Creek high
39	172.3640	12/10/82	F	Ad	none	Horse Mountain	04/04/84	Winterkill	Grieve's pasture (17 yrs)
40	172.3025	12/17/82	F	Calf	G1304	Horse Mountain	10/15/83	Harvested	West Huston Park
41	172.2380	12/10/82	F	Ad	none	Horse Mountain			
42	172.2670	12/26/82	F	Ad	G1307	Deep Gulch Ridge			
43	172.2885	12/28/82	F	Calf	G1308	Cow Butte	10/16/83	Harvested	Green Ridge
44	172.3133	12/26/82	F	Ad	G1305-G1306	Deep Gulch Ridge			
45	172.3605	12/06/83	F	Ad	none	Horse Mountain	05/14/84	Winterkill	Coal Bank Draw
46	172.3321	12/03/83	F	Ad	none	Horse Mountain			
47	172.2386	01/02/83	F	Ad	G1311-G1312	Garden Gulch			
48	172.3385	12/03/83	F	Ad	none	Horse Mountain	10/22/84	Harvested	Battle Mountain
49	172.3435	12/03/83	F	Calf	none	Horse Mountain	04/24/84	Off Elk	Little Horse Mountain
50	172.3635	01/02/83	F	Ad	G313-G1314	Deep Gulch Ridge			
51	172.2440	01/06/85	F	Ad	none	Deep Gulch Ridge			
52	172.2732	02/08/83	F	Ad	G318-G1318	Atlantic Rim	08/25/83	Off Elk	Deep Creek
53	172.2842	01/05/83	F	Ad	G1317	Deep Gulch Ridge			

Table 2. Elk Telemetery Capture Record on the Little Snake River Known Recoverable Coal Resource Area and Independence Ridge. (Cont.)

Collar No.	Frequency	Installation Date	Sex	Age	Ear Tags	Location	Date Off	Reason	Location
54	172.3089	03/19/84	M	Bull	B078-B079	Big Creek			
55	172.3671	03/22/84	F	Ad	B089-B090	Big Creek			
56	172.3938	02/15/83	F	Ad	none	Atlantic Rim	10/31/84	Harvested	Littlefield Creek
57	172.3323	12/11/83	F	Calf	none	Deep Gulch Ridge			
58	172.3382	12/11/83	F	Calf	none	Cow Butte			
59	172.3455	12/11/83	F	Ad	none	Cow Butte	10/27/84	Winterkill	Green Ridge
60	172.2447	12/07/83	F	Ad	none	Horse Mountain			
61	172.2290	12/15/83	F	Ad	none	Deep Gulch Ridge			
62	172.2732	12/07/83	F	Ad	none	Horse Mountain			
63	172.2885	12/23/83	M	Bull	none	Deep Gulch Ridge	04/24/84	Winterkill	Deep Gulch Ridge
64	172.3146	01/02/85	F	Ad	none	Horse Mountain			
65	172.3622	01/04/85	F	Ad	none	Horse Mountain			
66	172.4000	12/03/83	F	Calf	none	Horse Mountain	09/04/84	Off the Air	Circle Bar Battle Cr.
67	172.1400	02/02/84	F	Calf	none	Atlantic Rim	07/23/84	Off Elk	Cabin Draw
68	172.8010	01/30/84	F	Ad	none	Atlantic Rim	10/24/84	Harvested	Jack Creek
69	172.2840	12/07/83	F	Ad	none	Horse Mountain			
70	172.2685	02/16/85	M	Bull	none	Big Creek			
71	172.2375	03/10/85	M	Bull	none	Big Creek			

Table 2. Elk Telemetery Capture Record on the Little Snake River Known Recoverable Coal Resource Area and Independence Ridge. (Cont.)

Collar No.	Frequency	Installation Date	Sex	Age	Ear Tags	Location	Date Off	Reason	Location
72	172.2605	12/21/83	M	Calf	none	Deep Gulch Ridge	10/30/84	Shot	Battle Mountain
73	172.2958	12/07/83	F	Calf	none	Horse Mountain	03/19/84	Winterkill	Little Snake River
74	172.3126	01/14/85	F	Calf	none	Deep Gulch Ridge	02/28/85	Off Elk	Low Deep Gulch Ridge
75	172.3679	01/11/85	F	Calf	none	Deep Gulch Ridge	03/11/85	Off Elk	Upper Wild Cow Creek
76	172.3899	01/21/85	F	Ad	none	Atlantic Rim			
77	172.2894	01/27/85	F	Ad	none	Atlantic Rim			
78	172.3128	01/04/85	F	Ad	none	Horse Mountain			
79	172.3453	01/04/85	F	Ad	none	Horse Mountain			
80	172.2882	12/21/84	M	Bull	none	Horse Mountain			
81	172.2335	03/24/84	M	Bull	B091-B092	Big Creek	10/20/84	Harvested	Crane Park, Colo.
82	172.2680	03/24/84	M	Bull	B084-B085	Big creek	12/17/84	Off the Air	Holroy Park
83	172.2875	12/16/83	M	Calf	none	Deep Gulch Ridge	04/24/84	Winterkill	Deep Gulch Ridge
84	172.2624	01/04/85	F	Ad	none	Horse Mountain			
85	172.1400	01/18/85	F	Ad	none	Deep Gulch Ridge			
86	172.2605	01/24/85	F	Calf	none	Deep Gulch Ridge			

the north end of the KRCRA. Of these, 2 calves and 7 cows were trapped on Atlantic Rim. Two of the cows were drugged from a helicopter.

The mortality of telemetered elk over the study period of January 1981 to May 1985 were as follows:

	Marked elk available			Harvest			Probable harvest			Collar or signal loss			Wounded lost			Winter kill			Percent harvest or died
Year	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	
1981	2	6	8	0	3	3	0	0	0	1	0	1	1	0	1	0	0	0	50
1982	5	16	21	5	4	9	0	1	1	0	1	1	0	2	2	0	0	0	52
1983	4	24	28	3	3	6	0	2	2	0	1	1	0	2	2	0	0	0	32
1984	7	34	41	1	5	6	0	2	2	1	1	2	1	1	2	3	6	9	41
1985	4	32	36							0	2	2							

The low number of bulls surviving the hunting seasons is a reflection of the heavy hunting pressure on the bulls. Two large bulls that were trapped on the east side of Independence Ridge south of Big Creek survived 1 hunting season. One spike (06) from the south end of the KRCRA survived 1 hunting season and then winterkilled. One branch antlered bull (16) from the north end of the KRCRA survived the 1981 hunting season, but was harvested the next year. Two spikes were found dead from wounding loss during the hunting season. One (5) was trapped near Divide Peak in 1981 and died on the east side of Independence Ridge about 2 miles south into Colorado in October 1981. The other spike (72) was trapped as a calf on Deep Gulch Ridge on the north end of the KRCRA in December, 1983 and found dead on the south side of Battle Mountain in late October 1984.

Two male calves, one from each end of the study area, lost their collars during the first winter after installation. One bull (82) trapped in 1984 at Big Creek survived a hunting season on Independence Ridge, but the batteries died in the collar that December.

The survival of telemetered cows through the hunting seasons was undoubtedly affected by hunting season regulations. During 1981 there was a general open season for bulls and 900 permits for anterless elk from October 15 to 31. The season for the 700 anterless elk permits for the Sierra Madre range and the KRCRA south of McCarty Canyon in Wyoming extended to November 10.

The same seasons applied in 1982, but there were only 780 anterless elk permits, with an extension to November 10 for 500 on the Sierra Madre range and the KRCRA south of McCarty Canyon in Wyoming.

In 1983 the anterless elk permits were reduced to 630 and only 250 extended to November 6 on the west side of the Sierra Madre Range and south of McCarty Canyon on the KRCRA. There were further reductions to 560 anterless elk permits in 1984 with 300 for the Sierra Madre Range and south of McCarty Canyon with no extended season beyond October 31.

Hunter harvest was calculated by the Wyoming Game and Fish Department to be 896 for 1979, 1,161 for 1980, 852 for 1981, 703 for 1982, 545 for 1983, and 597 for 1984.

Harvest of telemetered cows averaged 38 percent over 4 hunting seasons. Cow 31 from the Divide Peak area has survived 4 hunting seasons. Only 3 of 7 female yearlings survived their first hunting season, and Cow 31 must have learned a good lesson the first year as a calf to have survived 3 additional years. Two cows from the south end of the KRCRA survived 3 hunting seasons. Six cows from the south and 7 cows from the north end of the KRCRA survived 2 hunting seasons. Two out of the 3 telemetered cows trapped at Big Creek survived the 1984 hunting season.

Three cows were known wounding losses. All three 3 residents of the winter range on the north end of the KRCRA and were killed in that area. Cow 19 was found dead on the west side of Miller Hill in October 1982 in the mountain shrub and aspen type. Cow 12 died in Snowshoe Canyon on Atlantic Rim in the mountain shrub and aspen type in October 1983, and cow 15 died in the aspen on the north side of Rendle Butte in October 1984.

There is some speculation why these were the only telemetered cows shot and not harvested. The permits in this unit are for any elk which could allow the hunter to shoot at the animals without identification of sex or age. The hiding cover is rather small (5 to 30 acre) patches of

well scattered aspen with some understory of mountain shrub, which are separated by long distances of sagebrush. When elk are forced out of this hiding cover, they often are in view for long distances which allows the hunters to take long-range shots. The reason for wounding loss may be a combination of these factors. Perhaps a designated-sex permit would help alleviate the problem.

Helicopter Elk Counts

Two complete elk counts from a 3-seat helicopter were made during the winters of 1982, 1983, 1984, and 1985, on the KRCRA by a Wyoming Game and Fish Department biologist and the principle investigator. The first count was made in either February or March when calves and bulls were easily classified. This count also coincided with the middle of the winter when elk were distributed on the major winter use areas. A high percentage of the winter elk population was classified with the exception of 1984, when high winds forced abortion of 2 flights on Atlantic Rim.

The data from the helicopter flights are shown in Table 3. There were some definite fluctuations in the number of elk seen each year. The variation in the Horse and Battle Mountain area on the south end of the KRCRA was both a reflection of elk movement back and forth across the Colorado-Wyoming state line and the mortality associated with the severe winter of 1984.

The usual procedure was to only count elk for one mile into Colorado. Because we know that telemetered elk and their associates move farther into Colorado, the arbitrary 1-mile boundary could cause the elk count to vary. The May 10, 1984 count was down by several hundred elk. The area between Slater Creek and Baker Peak between 2 and 5 miles into Colorado was searched in May 1984 and 336 elk were seen and added to the total. There was considerable mortality during the February to May period (7 out of 18 telemetered elk died, including a calf and 2 cows that were over 14 years old) so a lower count was expected. It was surprising to have the count in 1985 return to about normal. A good calf crop, lighter hunter harvest, and a milder winter that allowed the elk to stay in Wyoming evidently made up for the loss.

Table 3. Elk counts from Helicopter.

Area	Elk seen February & March 1982	1983	1984	1985	April & May 1982	1983	1984
South end - Horse Mountain/Battle Mountain							
South of Little Snake River	232	231	781	167	2	197	433**
Battle Mountain and east	307	575	153	487	545	702	219
Sugarloaf Mountain	32	0	12	0	0	0	0
Horse Mountain and west	468	291	122	278	191	201	118
Big Gulch-Savery-Sandstone-Hells	52	195	16	171	367	185	80
Loco Creek	67	125	81	86	102	126	47
Totals	1,158	1,417	1,165	1,189	1,207	1,411	897
North end - Cow Creek Complex/Atlantic Rim							
Cherokee to Deep Gulch	222	71	139	102	133	107	139
Cow and Rendle butte	29	12	59	12	39	319	59
Cow Creek	46	21	0	0	0	0	0
Cabin Draw-Muddy Creek-Sand Hills	198	121	67	131	264	101	26
Miller Hill	65	70	0	335	0	0	0
Atlantic Rim	223	439	*	418	6	13	590
Totals	783	734	265	998	422	540	814
Grand Total of study area	1,941	2,151	1,430*	2,187	1,649	1,951	1,711

*Atlantic Rim not flown due to high winds.

**Slater Creek to Baker Peak between 2 and 5 miles in Colorado counted.

The classification each year was made from the helicopter during the first flight. The data are presented in Table 4. The cow/calf ratios are consistent for the south end of the KRCRA, but show some unusual and unexplained variation on the north end. The overall average of 50 calves per 100 cows is considered good reproduction for this range.

The low percentage of bulls, particularly branch antlered bulls, in the population is expected because of the heavy hunting pressure. There is no restriction on licenses for bulls and the classifications reflect the choice of hunters to harvest a bull if possible. In spite of the low number of bulls in the breeding population, the calf crop is still within the normal limits for the area. The percentage of bulls in the winter population of elk at both ends of the KRCRA reflects the high hunting pressure in all units. It may also reflect the overlap of elk from both winter ranges on fall range where hunting unit boundaries may not control hunting pressure.

A helicopter elk count was made in the Independence Ridge area of Wyoming from Woods Mountain south to the Colorado state line on March 20, 1985. There were 291 elk seen and 225 were classified (131 cows, 68 calves, 19 spikes, and 7 bulls). This amounts to 52 Calves/100 cows, with bulls 9 percent of the elk seen.

The total harvest for the last 5 hunting seasons is shown in Table 5. The number harvested from each hunting unit is controlled by size, accessibility, and number of antlerless permits issued. The 21 Baggs unit is considerably larger than any other unit and the 108 south Rawlins unit is the smallest. The elk harvested in the 13 Big Creek unit could be elk from 3 different wintering areas, namely, north and south end of the KRCRA and Independence Ridge according to the telemetered elk distribution. This same mixed harvest could occur in the 14 Hog Park unit. Elk harvested in the 15 Spring Creek unit, according to information from the telemetered elk, winter on the north end of the KRCRA. The large 21 Baggs unit holds the majority of the elk that winter on both ends of the KRCRA winter range. They move from the winter ranges to the large area of summer range on the National Forest.

Elk harvested on the south Rawlins 108 unit come from the resident population, unless an early heavy snow moves the elk off the Forest during

Table 4. Elk classified on the early helicopter flights.

Area	Years			
	1982 (80% elk seen) Classified	1983 (92% elk seen) Classified	1984 (70% elk seen) Classified	1985 (85% elk seen) Classified
Horse Mountain/Battle Mountain				
Adult bulls	14	9	7	21
Yearling bulls	45	71	34	28
Cows	567	818	741	613
Calves	274	389	374	223
Totals	900	1,287	1,156	885
Calves per 100 cows	48	48	50	36
Percent antlered bulls in population	7	6	4	6
Cow Butte Complex/Atlantic Rim				
Adult bulls	6	11	4	22
Yearling bulls	12	55	22	52
Cows	439	382	123	640
Calves	190	239	63	271
Totals	647	687	212*	985
Calves per 100 cows	43	63	51	42
Percent antlered bulls in population	3	10	12	8
KRCRA study area				
Adult bulls	20	20	11	43
Yearling bulls	57	126	56	80
Cows	1,006	1,200	864	1,253
Calves	464	628	437	494
Totals	1,547	1,974	1,368*	1,868
Calves per 100 cows	46	52	51	39
Percent antlered bulls in population	5	7	5	6

*No elk classified north of Cow Creek due to high winds.

Table 5. Elk harvest from the study area reported by the Wyoming Game and Fish Department.

Area	Mature bulls					Small bulls					Cows				
	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
13 Big Creek	36	17	33	11	20	15	10	17	10	12	47	30	48	41	43
14 Hog Park	13	34	22	12	53	35	45	35	52	14	56	45	32	22	21
15 Spring Creek	45	24	22	12	14	38	14	31	18	23	23	20	27	36	37
21 Baggs	113	98	66	79	130	163	149	164	100	108	412	267	117	76	78
108 South Rawlins	7	16	5	5	5	10	0	10	4	5	39	28	23	22	14
Totals	214	189	148	119	222	261	218	257	184	162	577	390	247	197	193

	Calves					Totals				
	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
13 Big Creek	9	20	9	6	11	107	77	107	66	86
14 Hog Park	9	5	3	2	4	113	129	92	88	92
15 Spring Creek	12	10	0	7	6	118	68	80	73	80
21 Baggs	74	15	34	23	6	762	529	381	278	331
108 South Rawlins	5	5	5	7	2	61	49	43	38	26
Totals	109	55	51	45	29	1161	852	703	543	615

October. This is an any-elk restricted permit hunting area so the number of elk harvested is closely controlled.

Total harvest declined from 1,161 in 1980 to 543 in 1983 and increased to 615 in 1984. The long season, number of antlerless elk permits, access, and weather conditions have been conducive to good harvest. Shorter seasons and fewer antlerless elk permits have reduced the harvest the last 2 years.

Winter Elk Distribution

Elk locations and sightings from December through March (for the 1980 to 1985 period) on the KRCRA study area are shown in Figures 2 and 3. The travels of elk followed by telemetry for the same period are shown in Figures 4, 5, and 6. The number of locations and elk seen for each year were as follows:

Winter	Times located	Elk seen	Number of telemetered elk
1980-81	75	1,359	4
1981-82	361	10,967	21
1982-83	248	7,868	28
1983-84	530	14,384	41
1984-85	415	14,445	34
Totals	1,629	49,023	130

The number of telemetered elk monitored was directly related to both the total number of sightings and number of elk seen. The number of elk in each sighting ranged from 1 to 1,000. The high count was from the Willow Creek feedline in Colorado on February 27, 1984. Even without including the high counts of elk on the south end feedlines during the heavy snow year of 1983-84, the average number of elk per sighting was still 32.

The KRCRA is divided into north and south winter ranges by the high, relatively level, plateau of Brown's Hill where snow accumulation on the cultivated fields apparently discourages elk use. These 2 areas are

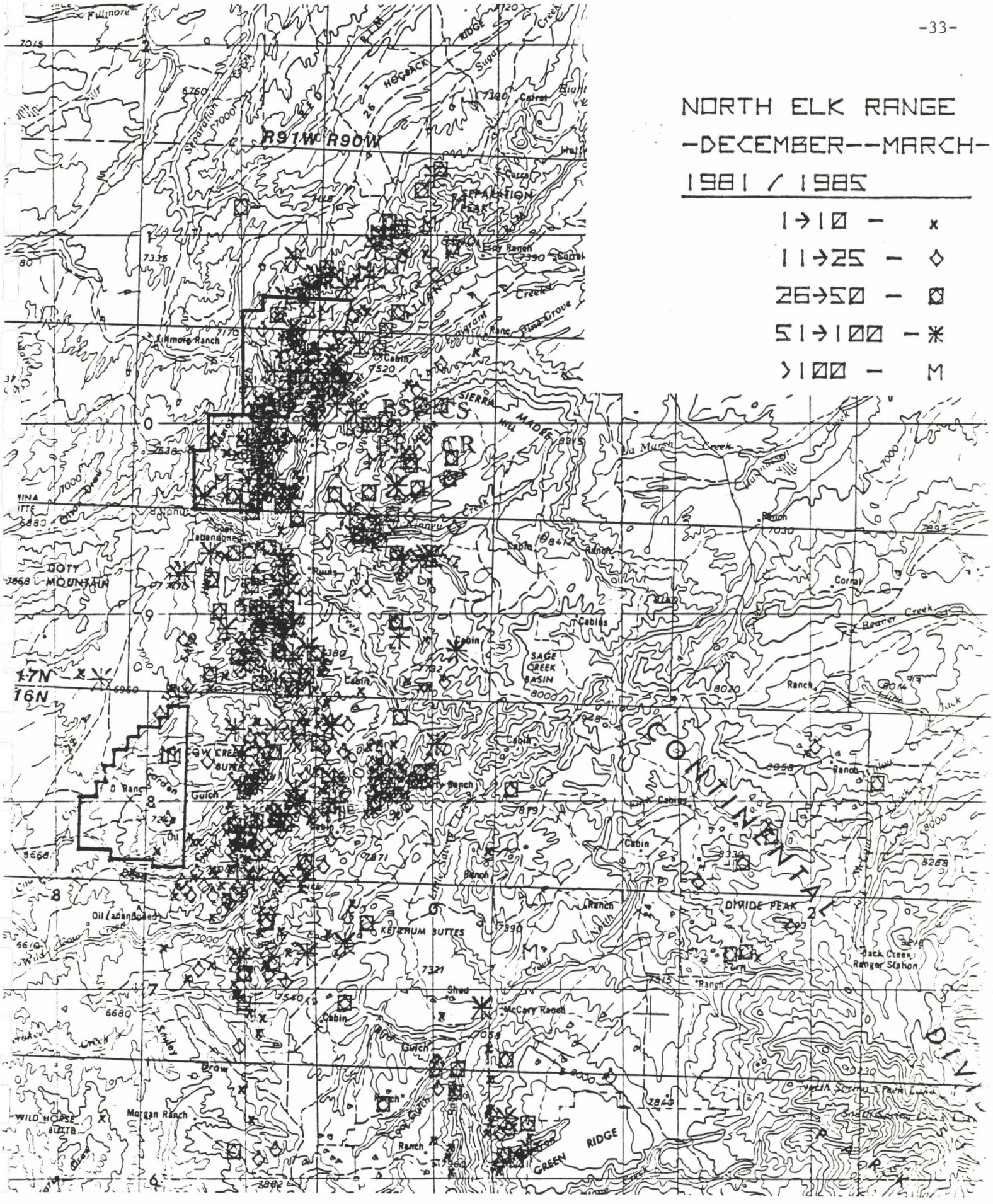

Figure 2. Elk seen on the north end of the KRCRA winter range, 1981-85.

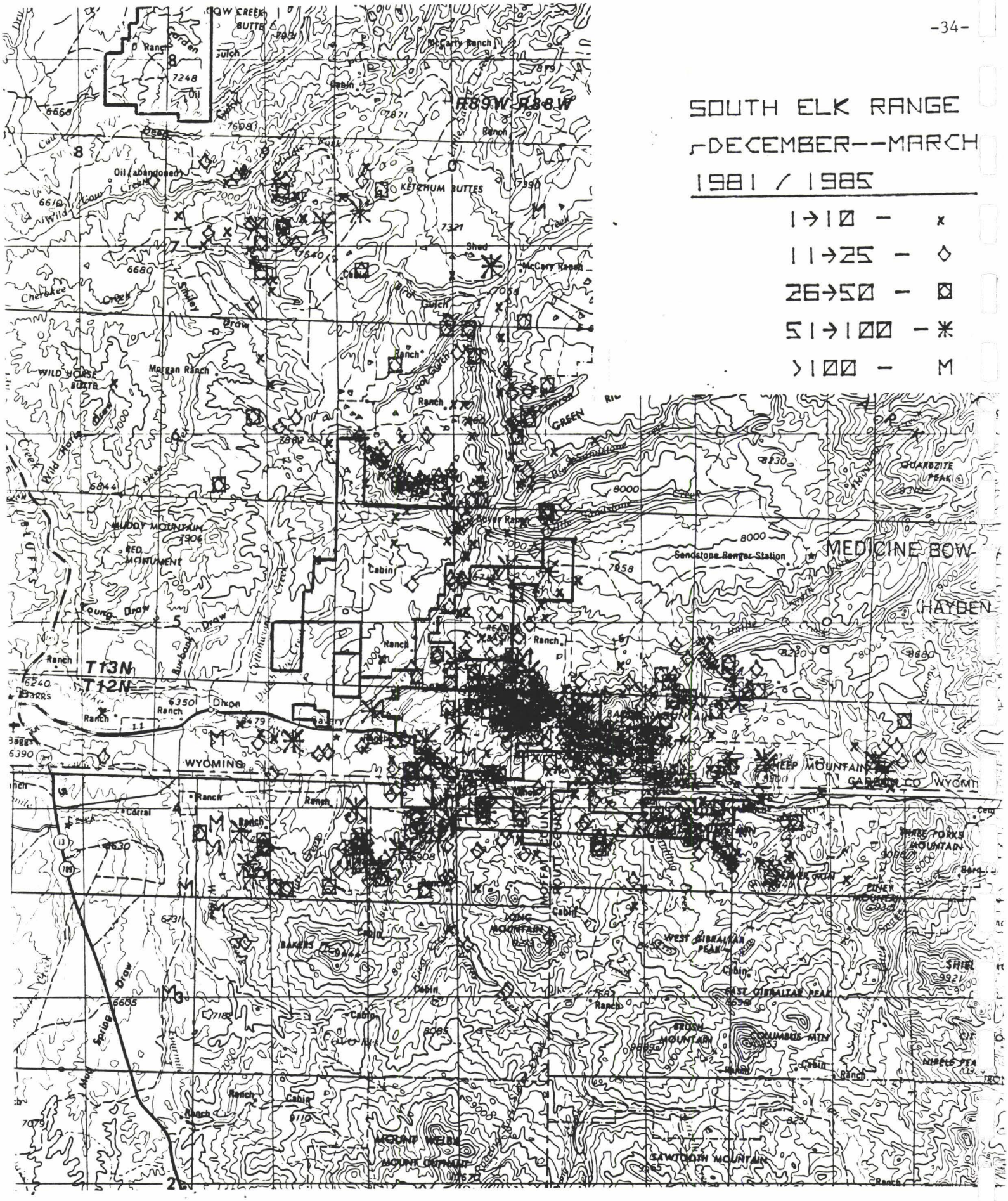

Figure 3. Elk seen on the south end of the KRCRA winter range, 1981-85.

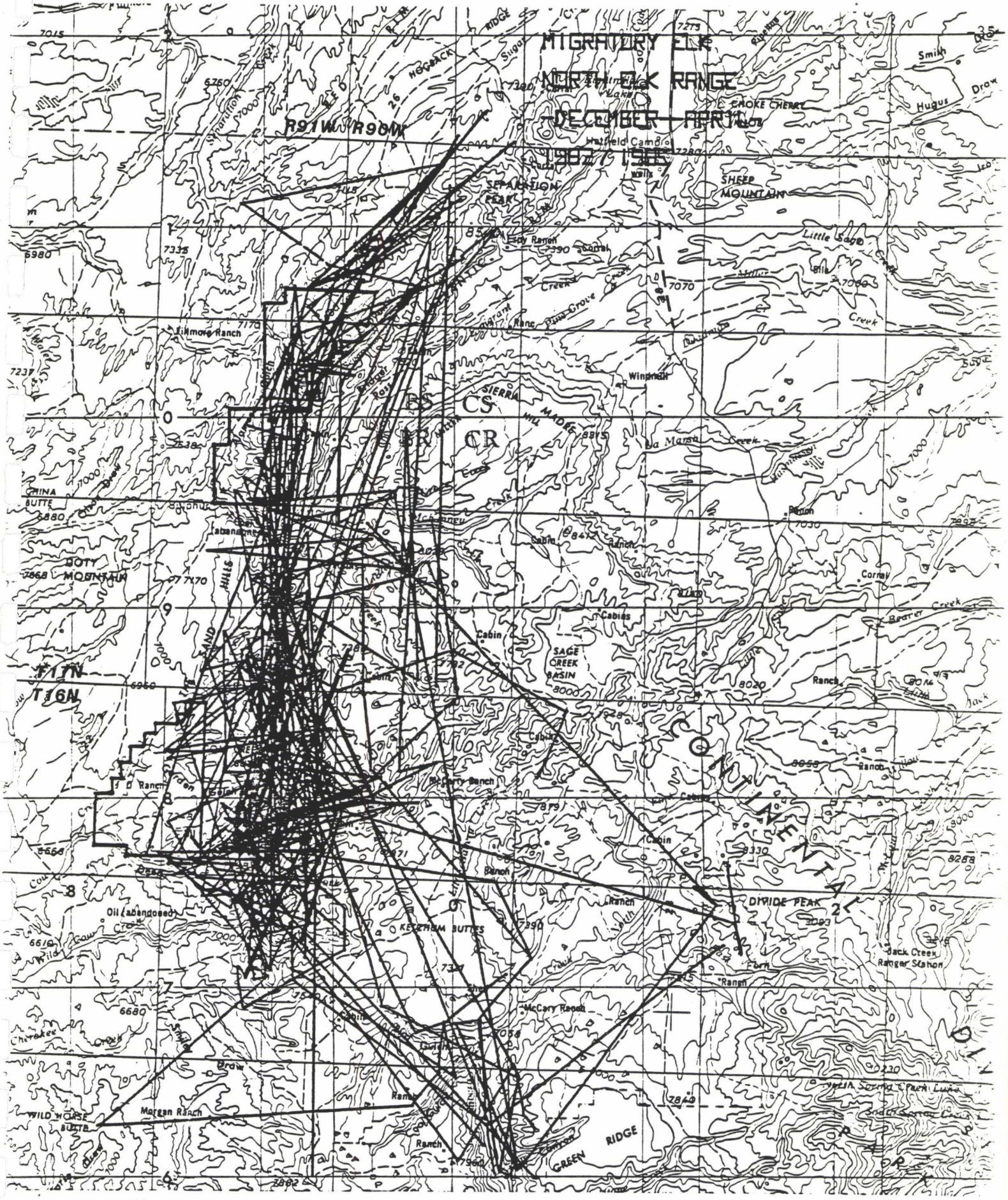

Figure 4. Winter movements of telemetered elk on the north end of the KRCRA 1982-85.

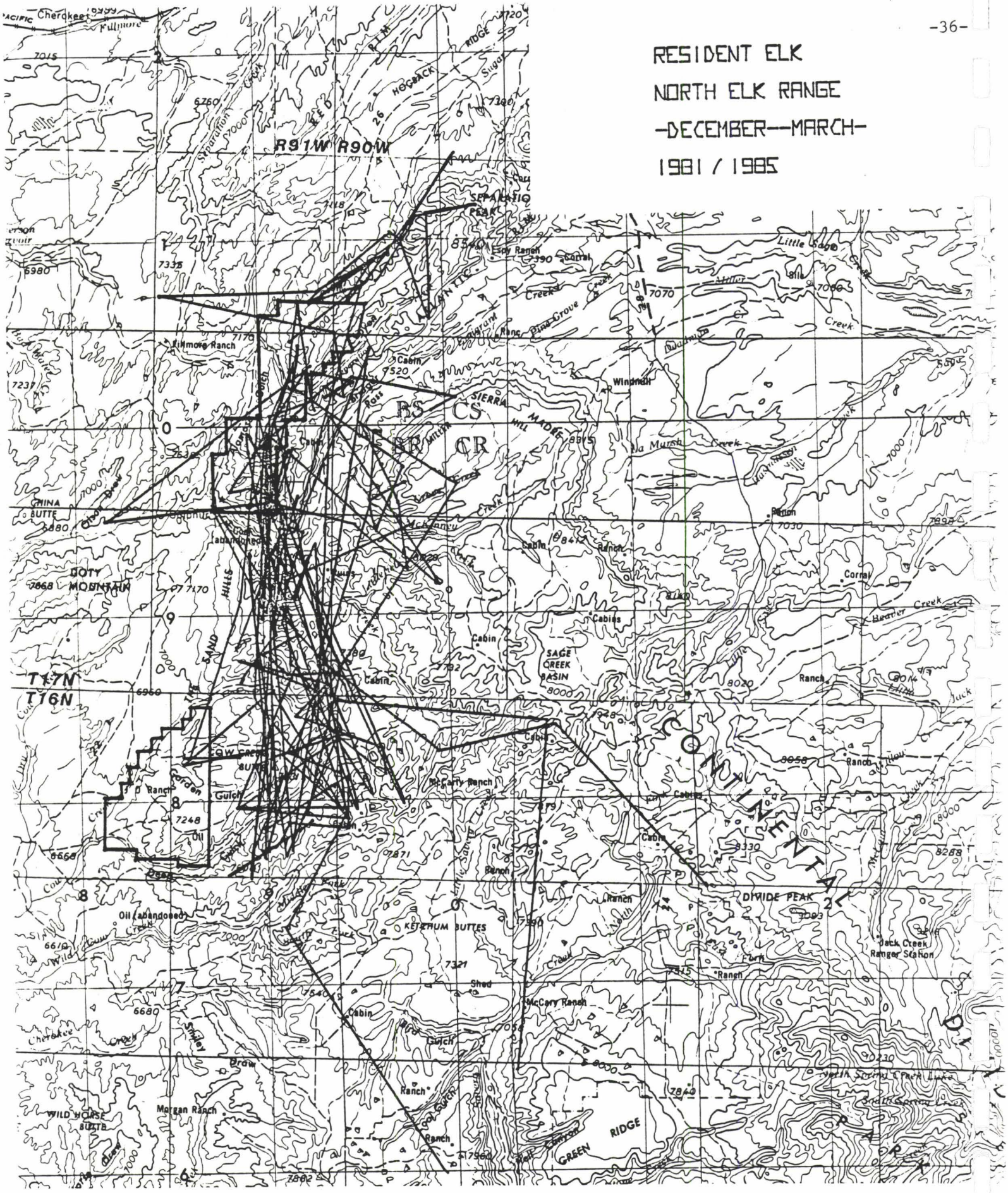

Figure 5. Winter movements of resident telemetered elk on the north end of the KRCRA, 1981-85.

Figure 6. Winter movements of telemetered elk on the south end of the KRCRA 1982-85.

discussed separately because of their differences in habitat components, such as human disturbance on the south end, and wild horses and more wind on the north end.

North end KRCRA

The high variation in snow accumulation during the 5 winters of the study had a direct effect on elk use of the winter range. The winter of 1980-81 was very mild with light snow cover. The winter of 1983-84 was one of the heaviest snow accumulation years on record. The other 3 winters were considered normal.

During the light snow winter the elk were able to use a very large range which included areas on the National Forest around Divide Peak and Green Ridge at elevations of 9,000 feet. Snow depths were not enough to force elk out of the forested areas to places where they could be counted. As a result most of the data were collected from the resident herd of 90 to 100 elk using the Atlantic Rim-Miller Hill-Rendle Butte-Cow Creek areas. The highest count (136) of elk was recorded on February 28, 1981 and included about 45 elk that apparently had moved from Divide Peak to Rendle Butte in early February. There were no restrictions to elk movements due to snow during the mild winter and the elk were not selective in their choice of aspect or slope for either feeding or resting Figure 7.

Our records indicate that the north end of the Atlantic Rim is very important for elk during heavier snowfall years. Our aerial photographs and the LAND-SAT photogrpahs taken during the heavy snowfall of 1973 and 1976, show less snow on the north end of Atlantic Rim than on other areas of the KRCRA. Low snowfall and higher winds on Atlantic Rim are undoubtedly the major influence on the elk using the area.

The elk showed a definite preference for areas with the least snow depth. Elk heavily use the rims and all of the south and west-facing slopes, but use the north to east-facing slopes less because of the deep drifts.

Figure 8 shows the percentages of resting and feeding elk in relation to aspect for 5 winters. They did not show a significant preference for aspect to feed or rest. About 50 percent of the elk were seen either feeding or resting on southeast to southwest facing slopes and another 30 to 35 percent were on west or northwest slopes. Westerly winds and

Figure 7. Elk feeding and resting use area on the north end of the KRCRA winter range.

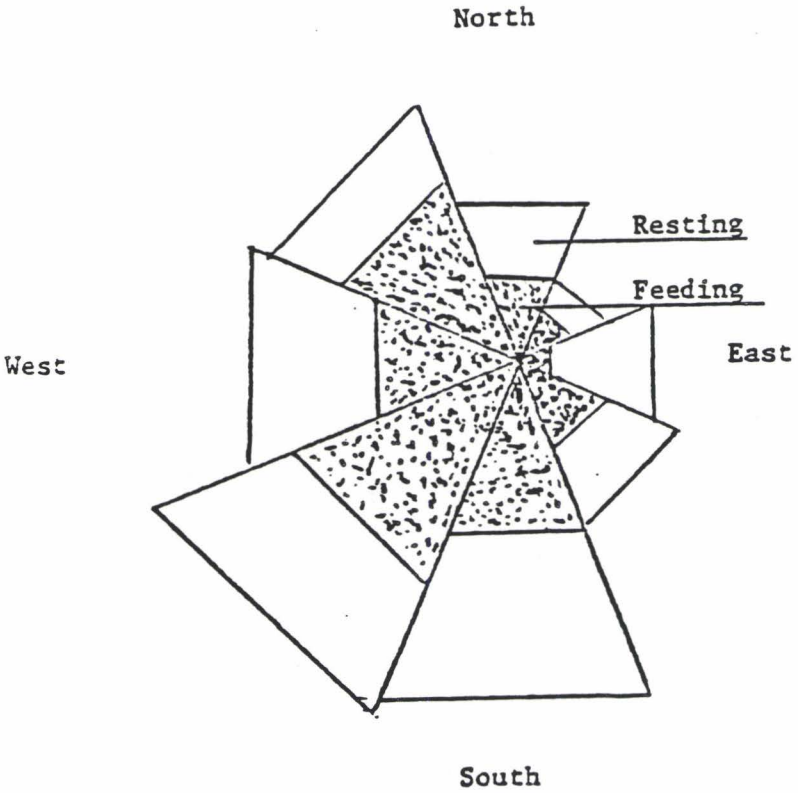

Figure 8. Percentages of elk use in relation to aspect for resting and feeding on the north end of the KRCRA winter range.

topography of the land help keep these aspects free of snow. Atlantic Rim, where the westerly sloping open ridges are exposed to the wind, is used heavily by elk. Some exposed ridges on Separation Peak, Miller Hill, Cow Creek, and Deep Gulch Ridge with prevailing southwesterly and westerly winds are also kept free of snow. Elk did 32 percent of their feeding and 24 percent of their resting on slopes under 20 percent. All other elk were on slopes greater than 20 percent.

The elk moved to the Atlantic Rim winter range each year in late December and early January when snow was 10 to 12 inches deep on the level at the mouth of Jep Canyon on Atlantic Rim. During the 3 normal winters between 300 and 750 elk spent February and March on wind-blown ridges in the Atlantic Rim-Miller Hill area. In 1984, 600 elk used Atlantic Rim for approximately 120 days.

As the snow started to disappear in March of these years, elk moved south into the Cow Creek Complex area which consists mainly of the Cow Creek, Deep Gulch and Wild Cow Creek drainages. The elk migrated in the middle of March in 1982, which was a lighter snow year, but they didn't move south until the last week of March in 1983 and 1985. Most of the elk stayed south of Squaw Canyon on the west side of Atlantic Rim during the 1981-82 and 1982-83 winters, but 243 elk were counted north of Squaw Canyon on March 18, 1985.

During the severe winter of 1983-84, the 590 elk counted on Atlantic Rim on April 4, 1984 did not start moving south to the Cow Creek Complex until early May. At least 376 of these elk were north of Squaw Canyon, and 163 were in one group 1.5 miles north of Separation Peak. The snow distribution patterns showed that the elk responded to snow depth. The area north of Separation Peak stayed relatively free of snow, as did the wind blown ridges. Snow completely covered the area to the south and east, except for the steep south facing slopes of Muddy Creek at the southeast end of Atlantic Rim where 90 elk were found. Also during April of 1984, another 26 elk were on the ridge east of the sandhills and 198 elk were in the Cow Butte and Deep Gulch Ridge area taking advantage of open south slopes and ridge tops.

The rest of the elk on the north end of the KRCRA spend the winter in the Cow Creek Complex. They too use the wind-swept ridges and south facing

slopes to keep out of the deeper snow. The heavier the snow the more restricted the range. Elk were found only in the sandhills part of the Cow Creek Complex during February and March 1983. They were scattered in groups of 27 to 80 elk and did not stay in the same area for more than a week. No deep snow was in the sandhills in 1981-82 or 1982-83, but there was complete snow cover in 1983-84 and 1984-85. No elk were seen from the helicopter in the sandhills 1981-82 but some might have been missed. In 1983, 83 elk (3 telemetered) using the sandhills were seen from the helicopter.

Habitat types used by elk on the north end of the KRCRA during the winter were as follows:

	Percent of locations		
Type	Feeding (380 locations)	Resting (391 locations)	Feeding and resting (186 locations)
Sagebrush/grass	89	89	94
Mountain shrub	6	5	3
Aspen	3	5	3
Sandhills	2	2	-

Relative use was approximately equal to availability except for aspen. Snow depths in the scattered small aspen prevented elk use in normal or heavier snowfall years. During the mild winter of 1980-81 elk were seen feeding in aspen 5 times, (involving 98 elk) and in sagebrush-grassland 15 times (involving 268 elk). The elk were frequently seen resting in aspen when the snow was less than 12 inches deep.

The use on the sagebrush/grass type in normal winters was not uniform over the winter range because of snow accumulation in the bottoms, on north facing slopes, and on the lee sides of hills. Even during the light snow year there was some sagebrush covered with snow for a short period of time.

Aerial photos, taken with the 35 mm camera system of sample strips of known elk use areas, recorded snow distribution periodically throughout the winters of 1982-83, 1983-84, and 1984-85. The photos were taken a few days after a storm to allow exposed ridges and slopes to become bare, if possible.

Many areas did not become bare during the heavy snow winter of 1983-84. The percentages of available elk use areas as determined by snow cover and elk distribution are shown in Table 6. The elk use sites were identified as bare ground and fringe areas where vegetation could be seen protruding through the snow. Snow-covered vegetation areas were completely white with no elk sign. The elk showed no significant differences between feeding and resting in their selection of aspect, slope, and vegetative type so all use areas were considered for both feeding and resting.

Aerial photographs taken during the 1980-81 and 1981-82 winters from out of the window of the fixed-wing airplane show about the same snow distribution pattern except snow depths were much lighter in 1980-81, leaving much more area available for elk use. These photos were distorted, however, and difficult to use to quantify data.

When the aerial photograph negatives from 1983 were exposed through an enlarger onto the orthophotoquad 7.5 minute series Geological Survey maps, the snow-free and fringe areas closely corresponded with the very light shade of gray on the orthophotoquads. By using the multi-spectral processor Mode 700 MSP at the University of Wyoming, percentages of elk use areas were calculated from the light shade of gray areas on the orthophotoquads throughout the KRCRA elk winter range. Designated areas, percentages of area used by elk, and acres were as follows:

Area	Percent	Acres
Atlantic Rim-Miller Hill	37	7,769
Cow Creek Complex	43	15,686
Savery Canyon-Loco Creek	21	6,180
Horse and Battle Mountains	44	9,314

Although these percentages do not agree exactly with the aerial photographs, they are useful in showing location and areas of use during normal or drier years. The use areas from the 1984 data were predictably much smaller due to the heavy snowfall and colder temperatures.

It is apparent that elk winter range in most winters is less than 50 percent of the total area, and that the most important sites occur on the south facing and windswept slopes where plant production is low due to

Table 6. Percentages of elk use areas as measured from aerial photographs during the winter on the KRCRA.

Date	Atlantic Rim			Cow Creek Complex			Battle and Horse Mountains		
	Bare ground	Fringe	Total	Bare ground	Fringe	Total	Bare ground	Fringe	Total
Jan. 9, 1983	7	16	23						
Mar. 21, 1983	29	23	52	31	23	54			
Apr. 6, 1983	51	21	72	28	17	45	21	13	44
Mar. 19, 1984	4	8	12	2	3	5			
Apr. 16, 1984							12	12	24
Mar. 25, 1985	39	13	52	25	9	34	56	10	66

poorer soils and drought. Areas identified as primary elk feeding sites on the entire winter range are shown in Figures 9, 10, 11, and 12.

The elk used topographic features, rather than trees, to satisfy their thermal and security cover requirements. The small patches of aspen scattered throughout the Atlantic Rim area fill with snow during normal or heavy snow winters, and the few pine trees along the top of the west rim were rarely used by elk. No other tree cover was available. Human disturbance was very light so security was not a problem.

The elk on the north end of the KRCRA compete with about 180 wild horses during the winter. The two species used several of the same ridges and slopes in the Cow Creek Complex and were seen within the following distances of each other:

Distance	Number of sightings	Elk involved
50 yds to .25 mi	23	1,085
0.25 to 0.5 mi	60	2,241
0.5 to 1 mi	134	3,552

There did not appear to be social animosity between elk and wild horses The horses were usually on the more gentle slopes.

The major disturbance to elk by people on the north end of the KRCRA occurred in the Cow Creek Complex area where there are a number of oil wells to the west of the use areas. These wells are tended daily, so snowmobiles and people walking are at each well almost every day during the winter. No past history data was available, but elk were not seen closer than 1 mile to these wells during the study. The closest encounters occurred on the north rim of Deep Gulch Ridge west of Cow Butte.

A manuscript reporting elk response to 3 types of seismographic activities (vibrator trucks, drill and shoot, and above ground explosions) has been accepted for publication (Ward 1985). The vibrator trucks and drill and shoot operations were conducted up Deep Gulch and on the ridge west of Cow Butte, respectively. The elk moved back over the rim of the Deep Gulch, 0.5 mile away from the truck vibrators. The elk stayed over

Figure 9. Winter elk use areas on Atlantic Rim.

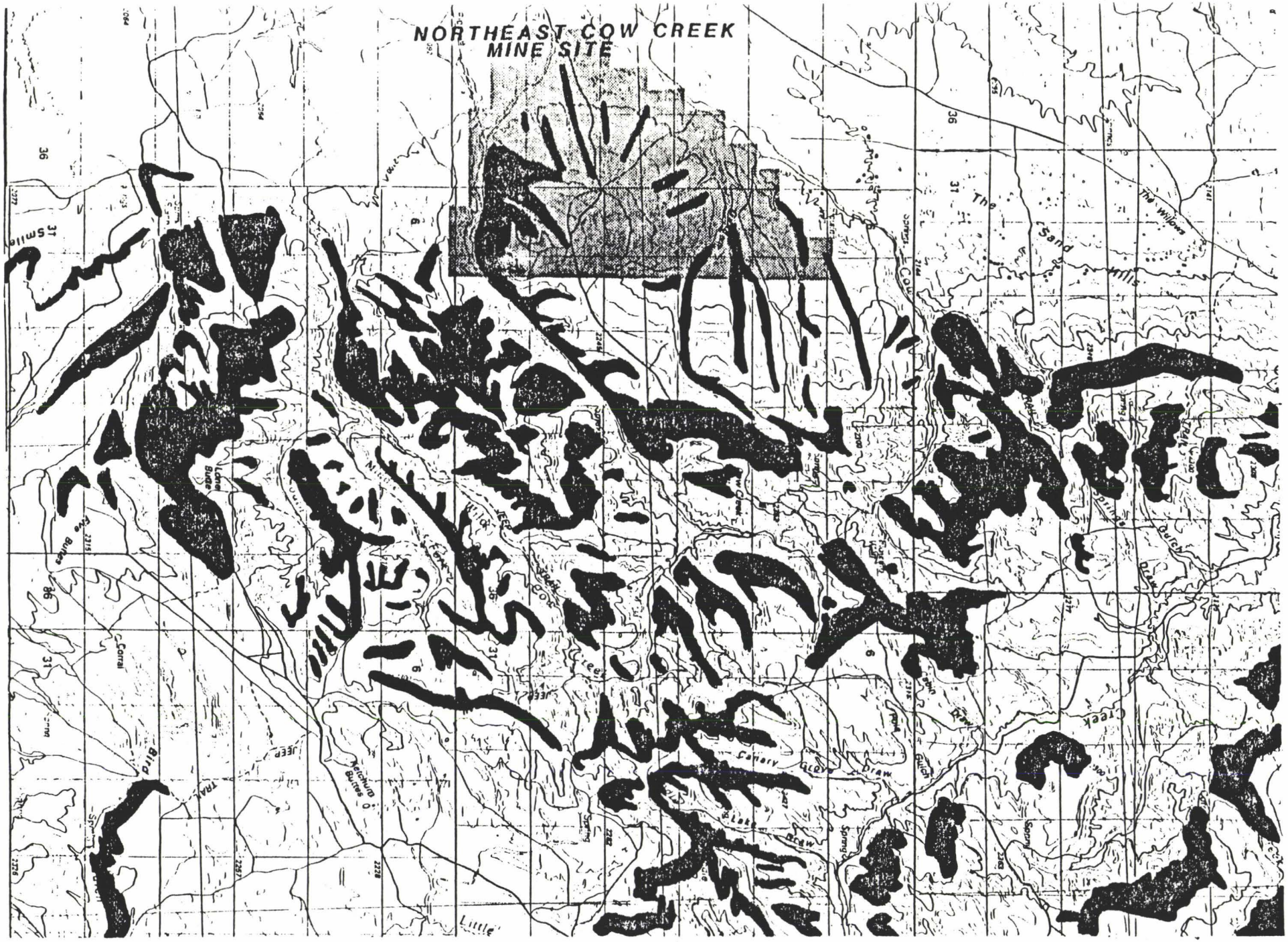

Figure 10. Winter elk use areas on the Cow Creek Complex.

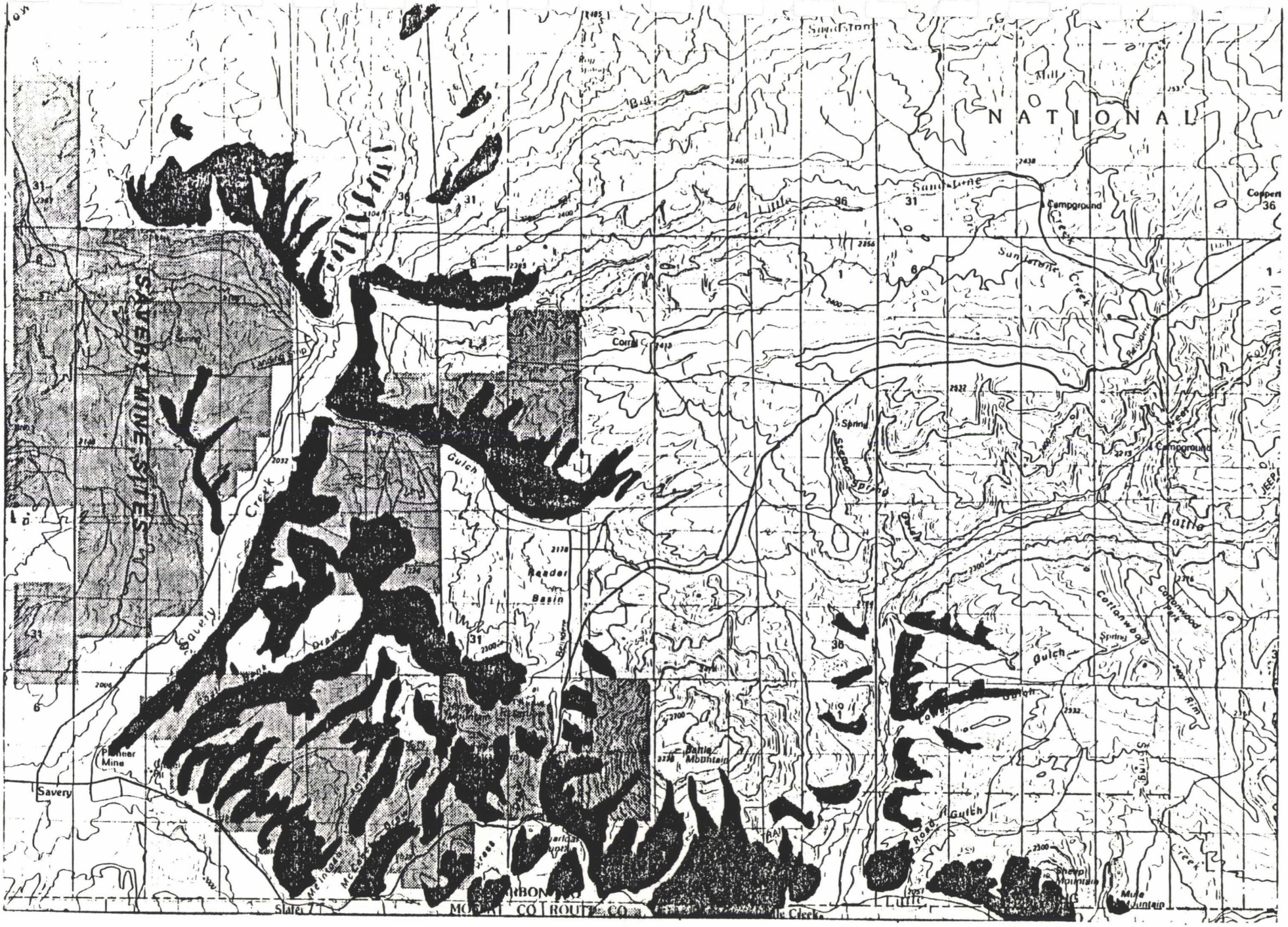

Figure 11. Winter elk use areas on the Horse and Battle Mountains and adjoining area.

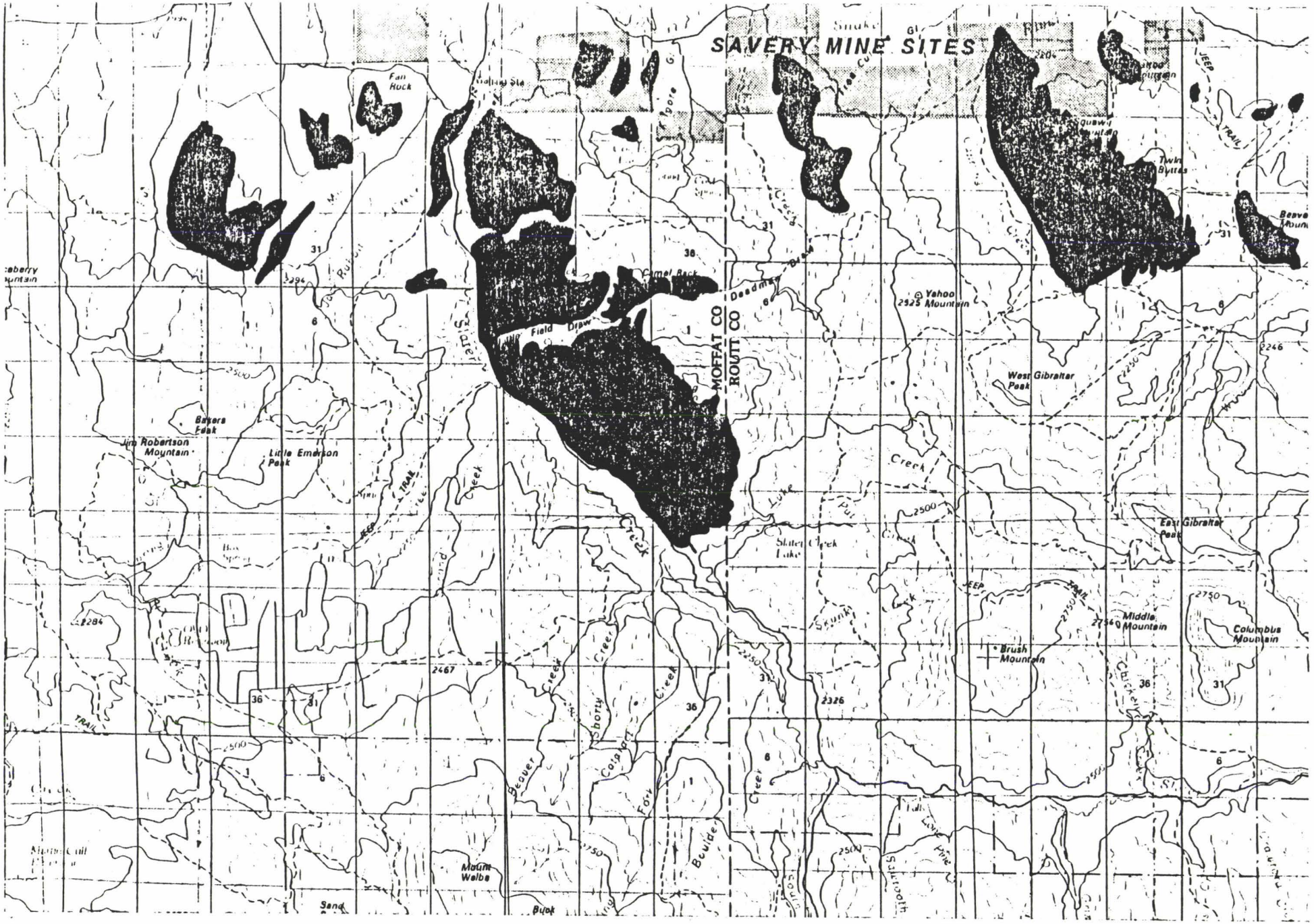

Figure 12. Winter elk use areas in Colorado near the Savery Mine sites.

the next ridge which was 2.0 miles away from the drill and shoot operation. Elk stayed where they couldn't be seen by the operators. They returned to the seismic activity areas a few days after the crews left.

The only other recorded human activity on the north end of the elk winter range during the winter was a little coyote hunting, and elk trapping and snow measurements done by research technicians. The elk were concerned with the moving snow machines, but they became more concerned when they saw people walking. The distances elk became disturbed varied with line-of-sight. When elk could see a long way, they moved out of sight of people walking at distances of 2 miles. If they were behind ridges or hills where they couldn't see people, it was possible to work within 0.5 mile or closer. Because of the absence of tree cover on this winter range elk use topography and distance for security or hiding cover.

South end KRCRA

The variation in snow depths and winter weather had a major effect upon elk on the south end of the KRCRA. During the very light winter of 1980-81 the elk mainly stayed in the Battle Creek and Sandstone drainages above the Forest boundary. No attempts were made to find the elk in Colorado, because at that time their movement patterns were not known well enough to suspect that very many of them came into Wyoming during the winter.

During the next 4 winters the elk on the south end of the KRCRA showed a definite preference for areas of use. Figure 13 shows the percentages of resting and feeding elk in relation to aspect. There was a significant preference to rest on the south and southeast slopes (42%) and to feed on the west to south slopes (72%). Only 32 percent of the resting and 29 percent of the feeding was on slopes less than 20 percent, and 25 percent of the resting and 40 percent of the feeding occurred on slopes greater than 40 percent.

Wind is not as prevalent on the south end, so the snow does not blow off the westerly facing ridges and drifting is not as common. Snow accumulates on the level and on north facing slopes when the weather stays cold.

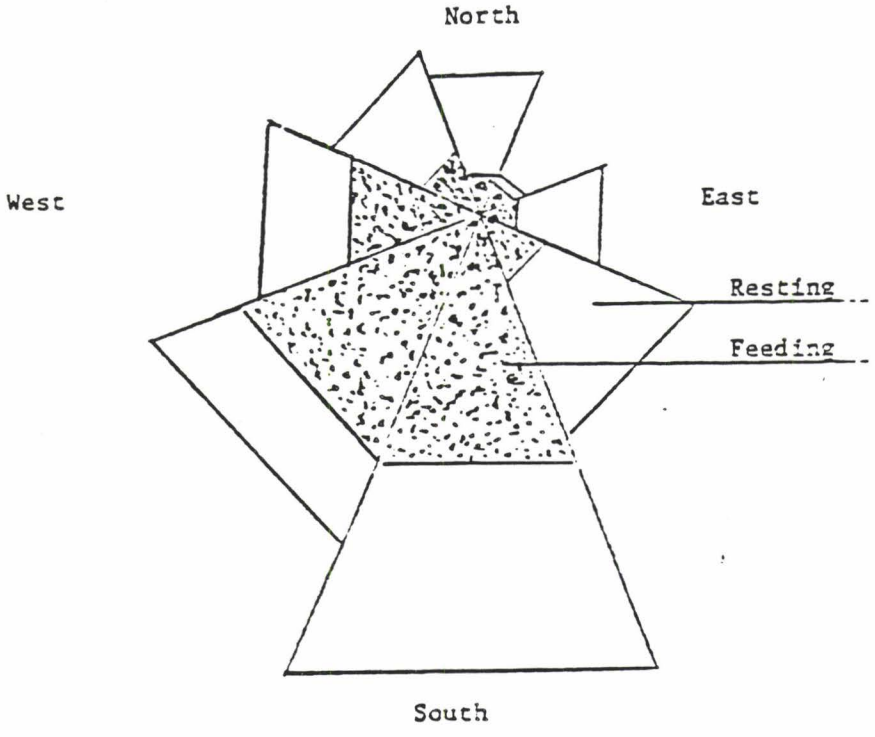

Figure 13. Percentages of elk use in relation to aspect for feeding and resting on the south end of the KRCRA winter range.

The steep south facing slopes have less snow due to exposure to the solar radiation (Buffo et al. 1972).

The elk on the south end used the following habitat types:

	Percentage of sightings		
Habitat types	Feeding	Resting	Feeding and resting
Sagebrush/grass	71	55	70
Mountain shrub	22	39	25
Meadows	4	5	4
Aspen	1	1	1
Other	3	3	1

Sagebrush/grass habitat was the most heavily used and its availability is the greatest, particularly during periods of heavy snow cover. Mountain shrub showed higher use for resting alone.

Elk were found both feeding and resting on 22 percent of the sites. Most of these feeding and resting elk were in sagebrush type habitat.

There is coniferous forest within a mile of some of the feeding sites on the south end, but during the winter there was no indication that elk were moving into the trees for either thermal or security cover.

The areas of concentrated elk use under normal snow conditions are the south facing slopes of Loco, Hells, Big and Little Sandstone, Big Creeks, Coal Bank Draw, and the south and west sides of Horse and Battle Mountains. The areas of use became much more restricted during the heavy winter of 1983-84. That year many of the elk moved into Colorado from Wyoming in December and stayed along the Little Snake River where they picked up feed from livestock operations or moved to the feedlines at Pothook and Willow Creek where the Colorado Division of Wildlife personnel fed them 640 tons of alfalfa hay.

The elk using the south end of the KRCRA winter range are an interstate herd and it was not possible to determine the total number of elk nor the number assigned to each state. Helicopter census flights usually only extended about 1 mile into Colorado.

Telemetery tracking data showed elk would come to the Horse Mountains from Wyoming and Colorado as the snow moved them down to the winter range. As snow accumulated, some elk moved to the southwest side of Baker Peak, 10

miles south into Colorado from their trap site in Wyoming. The number of elk leaving Wyoming and moving into Colorado was determined by snow depths.

Six primary elk crossing sites were identified along the state line. Three are southwest of the Horse Mountains, 1 south of the Horse Mountains, 1 west of Bob Greive's house, and another near the Slater Post Office. The other 3 are near Fly Creek on the south side of Battle Mountain, southwest of Sheep Mountain and at the Three Forks Ranch to the east.

During the normal years of 1981-82, 1982-83, and 1984-85 only 1 out of 9 (1982), 5 out of 14 (1983), and 4 out of 15 (1985) telemetered elk moved into Colorado. During the heavy winter year of 1983-84, 14 out of 18 telemetered elk were in Colorado during January and February.

During the heavy snow year there were several areas where the elk stayed in the bottoms of the Little Snake River along the state line.

Seven of the 18 telemetered elk died of starvation from March to May, 1984; 5 of these were in Colorado. Cow 11 was found dead on the Pothook feedline on March 2. Her teeth were sectioned and she was found to be 14 3/4 years old. Calf 73 was found dead on Horse Mountain on March 15. Cow 39 was photographed a few days before she died in Grieve's pasture along the Little Snake River on April 2. Her tooth section showed she was 17 3/4 years old. Spike 6 was found dead in William's pasture along the Little Snake River on April 12. Cows 24 and 27 were found dead on the south side of Chalk Bluffs in Colorado on April 24. They were judged to be 6 years old. Cow 45 died north of Coal Bank Draw, around May 25, and judged to be 3 years old. Since there were only 2 calves wearing telemetry collars on the south end of the study area during the rough winter and 1 winter-killed, the estimated 39 percent mortality is conservative. A close count of carcasses along the feedline at Willow Creek on May 9 found 38 calves out of 51 elk examined. This would indicate a higher mortality in calves. Flooding prevented additional surveys to get complete counts of carcasses.

The elk on the south end of the winter range are subjected to traffic and pedestrians, particularly in the Horse and Battle Mountain area. Sightings of elk and distances from human activity were as follows:

Distances	#sightings/ # elk (cumulative) Traffic	Pedestrians
≤ 25 yds	0	1/ 1 starving
≤ 50 yds	2/ 193	1/ 1
≤100 yds	4/ 269	1/ 1
≤200 yds	8/ 311	1/ 1
≤1/4 mile	42/2,227	17/184 (feed lines)
≤1/2 mile	103/3,760	29/671
≤ 1 mile	264/7,392	43/768
> 1 mile	487/9,021	Many

Elk in this area show similar aversions to pedestrians and traffic as found in other areas of southcentral Wyoming (Ward et al. 1980, Ward and Cupal 1979). They prefer to stay at least 1/4 mile from traffic and 800 yards from people walking, even under the extreme winter conditions of 1984 (Figure 14). They showed a similar response to people involved in the above ground seismographic operation explosions (Ward 1985).

The elk did not become concerned with the airplane or helicopter until they were directly approached on exposed ridges or hovered over within 600 ft. On several occasions resting and feeding elk were seen and photographed from the helicopter and airplane as we flew overhead at the same 600 ft distance.

Elk on the south end were found in close association with other herbivores. The number of sightings of elk and distances from other animals are as follows:

Distance	#Sightings/#elk (cumulative) Mule deer	Horses	Cattle	Domestic sheep
≤ 25 yds	2/ 237	1/ 18	2/ 31	1/ 9
≤ 50 yds	20/ 1,517	2/ 36	6/ 294	1/ 9
≤100 yds	30/ 1,885	3/ 66	6/ 294	1/ 9
≤200 yds	82/ 3,640	3/ 66	8/ 315	1/ 9
≤1/4 mi	229/ 6,648	15/ 69	32/ 892	8/ 38
≤1/2 mi	296/ 7,787	27/432	54/1,916	18/322
≤ 1 mi	363/10,554	46/934	140/4,449	38/864

Figure 14. Aerial of Horse Mountain on April 4, 1984 showing snow cover.

Elk and mule deer use some of the same winter range on the south side of Horse and Battle Mountain. Apparently there are no social intolerances. Compton (1975) came to the same conclusion.

Elk relationships with domestic livestock were somewhat asssociated with the severity of the winter. During the heavy snowfall winter of 1983-84 there were considerably more instances of close encounters than any other year. Where elk, horses, cattle, and domestic sheep were all being fed each day there were possible recordings of close association available after feeding each day. At one particular location on Slater Creek, all 4 species were being fed each day. Elk did not show concern about the presence of livestock.

The elk, however, kept their distance from people. The elk moved away while 2 men were putting out hay, but as soon as the men left the elk came trotting back to the feedline. Other people along the Little Snake River also fed the elk and livestock together (Figures 15a & b and 16). No conflicts between elk and livestock were recorded, other than competition for food (Figure 17).

Independence Ridge winter range

The elk winter ranges on Independence Ridge near Big Creek, Beaver Creek, and the north fork of the Encampment River are on the east side of the Continental Divide. The Encampment River and Beaver Creek area have steep south facing slopes with sagebrush and mountain shrub cover and receive some wind on the ridges. The Independence Ridge area has moderate south facing slopes which are covered with a good stand of tall sagebrush kept mostly free of snow because of the wind. The northerly slopes have stands of aspen and lodgepole pine.

The percentages of resting and feeding elk locations in relation to aspect for the winters of 1983-84 and 1984-85 on the Independence Ridge are shown in Figure 18. The major elk use areas are on northeast to south-facing exposures. About 61 percent of the feeding elk were recorded using south to southeast facing slopes, and 59 percent of the resting elk were found on northeast to east exposures. More than 78 percent of the feeding was on slopes over 20 percent. Resting elk were found on slopes greater

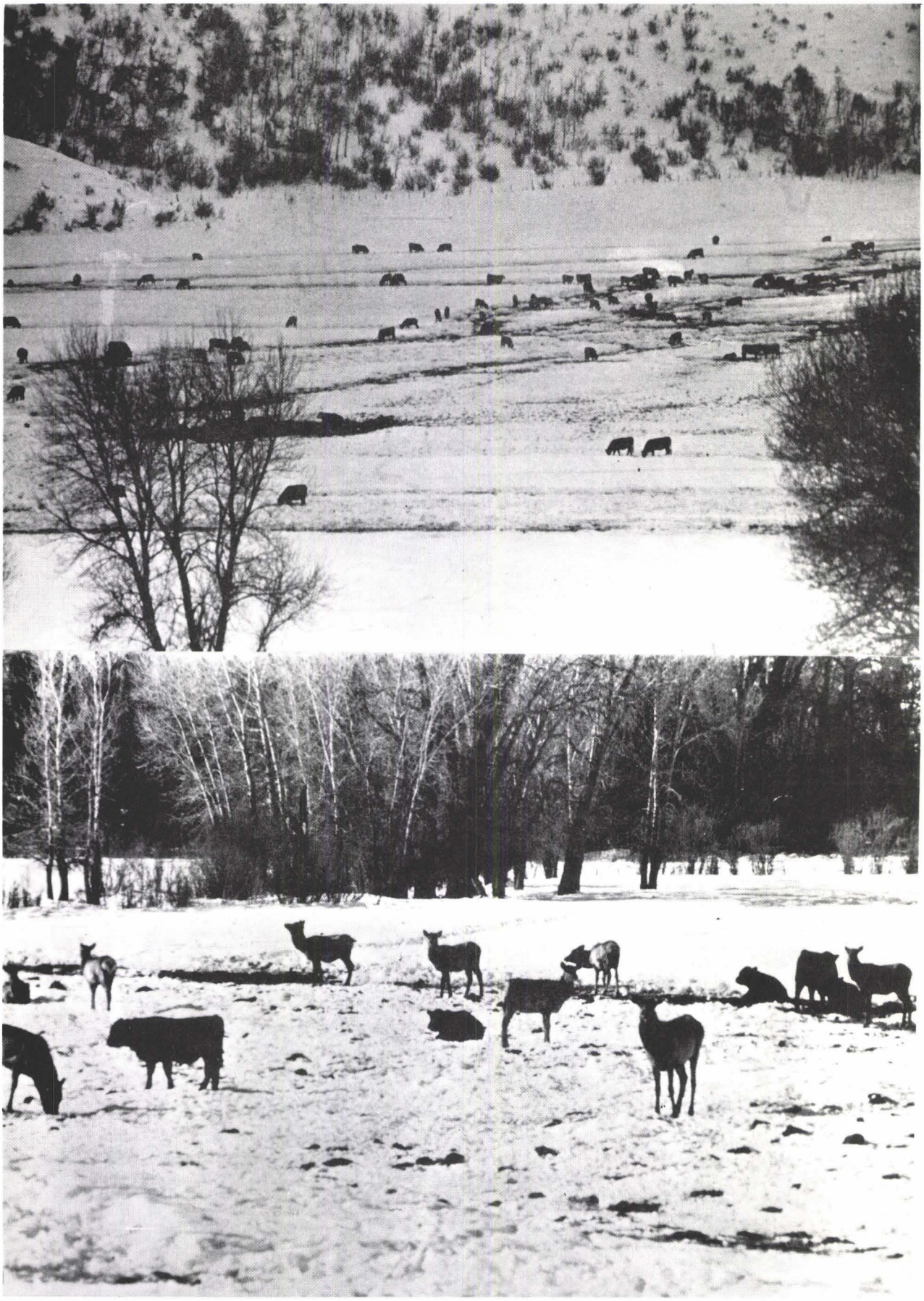

Figure 15 (a & b) Elk and cattle relationships on feedlines along the Little Snake River in 1984. (Note elk response to photographer in the pickup in lower photo)

Figure 16. Elk and horses feeding together at Slater.

Figure 17. Elk feeding from a haystack along the Little Snake River.

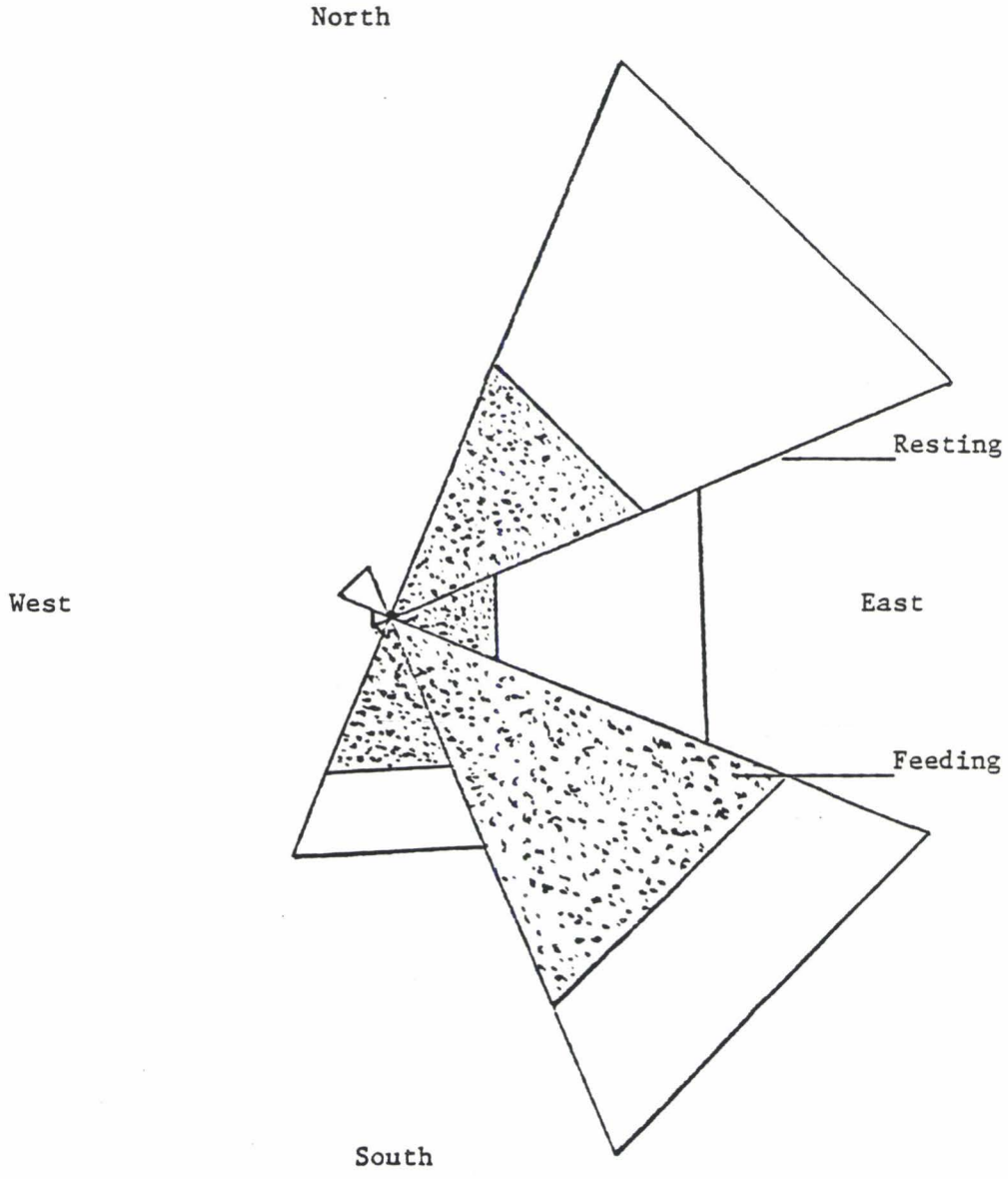

Figure 18. Percentages of elk use relative to aspect for feeding and resting on the winter range on Independence Ridge near Big Creek.

than 20 percent about 90 percent of the time. Elk fed in sagebrush, mountain shrub, and aspen. They rested about equally in sagebrush, mountain shrub, aspen, and lodgepole pine.

During the heavy snow winter of 1983-84, the Wyoming Game and Fish Department personnel fed the Independence Ridge elk. The feeding area was on the foothills at the base of the ridge and about 400 yards from the trees. The snow was 12 inches deep so the elk did not stay on the feedline all of the time.

The elk along the Independence Ridge from Colorado north to Beaver Creek were counted by helicopter on March 20, 1985. There were 163 elk seen north of Bear Mountain and 124 near Big Creek Canyon for a total of 287. There were 7 bulls, 19 spikes, 68 calves, and 131 cows classified.

Two cows trapped at Horse Mountain have spent 1 winter on the east side of the Continental Divide. Cow 10 spent the winter of 1983-84 in the north fork of the Encampment River with 14 other elk. Cow 22 spent this same winter with approximately 60 elk in Beaver Creek on the north end of Independence Ridge. Cow 10 lost her radio signal in the spring of 1984, but cow 22 returned to her previously used winter range at Horse Mountain for the 1984-85 winter.

Winter Range Utilization

Ten sets of 10 utilization cages (22.2 sq ft or 2.06 sq m) were placed on known winter elk use areas within the KRCRA. Each site was chosen to represent an example of habitat available to elk during normal winters. Cages were relocated in the fall of the year after domestic livestock were removed. Soon after the elk left their winter range the sites were sampled by clipping random plots to ground level, both inside and outside of each cage.

On the same sites, pellet group transect lines were established to determine relative animal abundance by species and year. The lines ran parallel to the cage line and consisted of 50 plots 1/100 acre in size. The plots were cleared of all fecal droppings each year they were counted. Cherokee Creek and the south fork of Wild Cow Creek were not sampled in 1984 because no elk use was recorded in this area. A summary of utilization and pellet group data is presented in Table 7.

Table 7. Winter forage utilization and pellet group counts KRCRA.

Location	Percent Utilization						Number of Pellet Groups								
	Graminoides			Browse			Elk			Deer			Horses		
	1983	1984	1985	1983	1984	1985	1983	1984	1985	1983	1984	1985	1983	1984	1985
Battle Mountain	20	50*	7	0	0	46	103	136	61	41	37	14	0	0	0
Little Horse Mountain	49*	44	46	39	83*	85	220	147	176	69	75	41	0	0	0
West of Horse Mountain	57*	33	19	85*	12	90	156	67	110	128	117	90	0	0	0
Coal Bank Draw	26	4	30	71*	0	32	79	20	34	43	26	84	0	0	0
Deep Gulch Ridge	66*	27	34	67*	20	62*	101	31	102	1	12	0	20	52	16
Cow Creek Ridge	0	63*	**	36*	***	**	21	18	**	1	0	**	10	49	**
Cherokee Creek	49	**	39	2	**	***	3	**	26	1	**	0	0	**	0
South Fork Wild Cow	0	**	26	34	**	51	8	**	6	0	**	0	0	**	0
Hay Gulch-Atl. Rim	55*	18	44*	0	2	54	39	11	24	0	0	0	0	4	3
Hodorff Draw-Atl. Rim	36	29	31	0	***	***	43	62	50	0	0	0	0	0	0

*Significant 0.5 level

**Not sampled-deep snow or cage damage

***Not available

Since elk distribution and available habitat changes with the amount of snow and weather conditions from year to year, it is difficult to predict the most desirable locations for utilization cages. Due to light snow accumulation the first year (1981) of the study, the elk used a very extensive area and many of them never moved off the forest. Little use was shown by exclosures. Three other years (1982, 1983, and 1985) had normal winters, and elk used all of the selected sites. The heaviest elk use areas occurred in the south at Battle and Horse Mountains and the Fan Rock area in Colorado, and in the north at Deep Gulch Ridge and the Atlantic Rim.

In 1984, the deep snow cover and cold weather changed the elk use pattern enough so that even the areas used heavily during normal winters were either used lightly or not at all. The feeding program in Colorado and the elk damage to haystacks along the Little Snake River complicated the utilization measurements on the south end of the study area. The areas that received heavy elk feeding use on Battle and Horse Mountains were the steep, narrow, rocky ridges exposed to the sun and wind. The most gentle slopes and ridges on the west side of Horse Mountain and Coal Bank Draw stayed covered with deep snow and were not used by the elk in 1984.

The majority of elk feeding in the Cow Creek Complex was concentrated on the south-facing slopes of Wild Cow Creek and Deep Gulch. The ridge between Cow Creek and Bear Gulch received heavy use from large concentrations of elk when the snow began to melt and the animals moved back from Atlantic Rim. The Sand Hills and Buck Springs areas were used for animal travel corridors between Cow Creek and the Atlantic Rim.

In 1984, more than 160 elk were seen north of Separation Peak where they stayed throughout most of the winter. Consequently, the elk use on the south end of the Atlantic Rim, particularly Hay Gulch, was down.

Pellet group densities were higher on the south end of the study area. These areas can support a higher density/unit area of big game animals due to the greater vegetation production capabilities of the existing mountain shrub vegetation.

Winter deer use is usually insignificant except for milder winters when both Coal Bank Draw and the site west of Horse Mountain in the southern part of the study area received more deer use than elk use. However, observations indicate that most of the deer use near these cage

sites occurs in early winter and early spring with little use during January and February.

Two sites, Deep Gulch and Cow Creek, receive considerable horse use. In fact, in 1984 there were more horse fecal droppings than elk droppings on both of these sites. Horses upset 9 of 10 cages at Cow Creek in 1985 and rendered this site useless for sampling.

Spring Elk Distribution

The spring period covers April, May, and June. The numbers of locations and elk seen were as follows:

Year	Locations	Elk Seen
1981	201	1,863
1982	165	6,177
1983	188	3,525
1984	345	5,259
Totals	999	16,824

The average number of elk seen per sighting was 17 for the 4 years. The average varied from a low of 9 in 1981 when spring came early because of light snow and the elk were widely disbursed, to 23 in 1982 when larger groups were seen in April and May.

The number of elk seen dropped considerably when leaves developed on the deciduous trees and elk moved to the coniferous forest at higher elevations. More elk were seen in 1982 and 1984 due to the late spring when they stayed on the winter ranges longer and plants developed leaves later.

North end KRCRA - Resident Elk

The elk using the winter and spring range on the north end of the KRCRA are divided into resident and migrant elk. The 60 to 100 resident elk stay in the Atlantic Rim, Miller Hill, and Rendle Butte area throughout the summer with the exception of a few telemetered elk and their associates that move to the forest during the hunting season. The 600 to 700 migrant elk move from the winter range to the forest during spring and spread out

over the Sierra Madre mountain range from north of Divide Peak to about 10 miles south in Colorado on both sides of the Continental Divide.

During the study, there were 9 telemetered resident elk (8 cows and 1 spike) tracked through spring. These elk were located 185 times, but only 71 times could they be seen. An average of 25 elk were seen these 71 times. The elk stayed in the Atlantic Rim-Miller Hill-Rendle Butte area but traveled extensively over that range (Figure 19). As the weather became warmer and leaves developed on the aspen, the elk became more closely associated with the trees, evidently for thermal cover primarily and hiding cover secondly. Even where there was no human activity, the elk still moved to the trees after the sunrise.

Figure 20 shows the relative use of the different aspects for feeding and resting by the resident elk. There was no significant difference in aspects used between feeding and resting. Seventy-seven percent of the feeding and 75 percent of the resting were on less than 20 percent slopes.

Feeding elk were found in sagebrush/grass 45 percent, aspen 38 percent, and mountain shrub 11 percent of the time. Resting elk used sagebrush/grass 56 percent, aspen 30 percent, and mountain shrub 8 percent of the time. Elk were seen feeding and resting in the same type of vegetation 8 percent of the time. The use of aspen increased as the season progressed. During the calving season, between May 20 and June 10, the elk were found in aspen 60 percent, sagebrush 28 percent, and mountain shrub 8 percent of the time.

Feeding elk were located various distances from tree cover during spring as follows:

	#Locations/#Elk seen (cumulative)	
Distance	Feeding	Resting
≤ 25 yds	58/ 95	29/ 13
≤ 50 yds	74/ 231	34/ 23
≤100 yds	83/ 254	36/ 31
≤200 yds	87/ 302	37/ 31
≤1/4 mi	93/ 304	37/ 31
≤1/2 mi	98/ 383	39/ 31
<1 mi	98/ 383	39/ 31
>1 mi	28/1,144	51/859

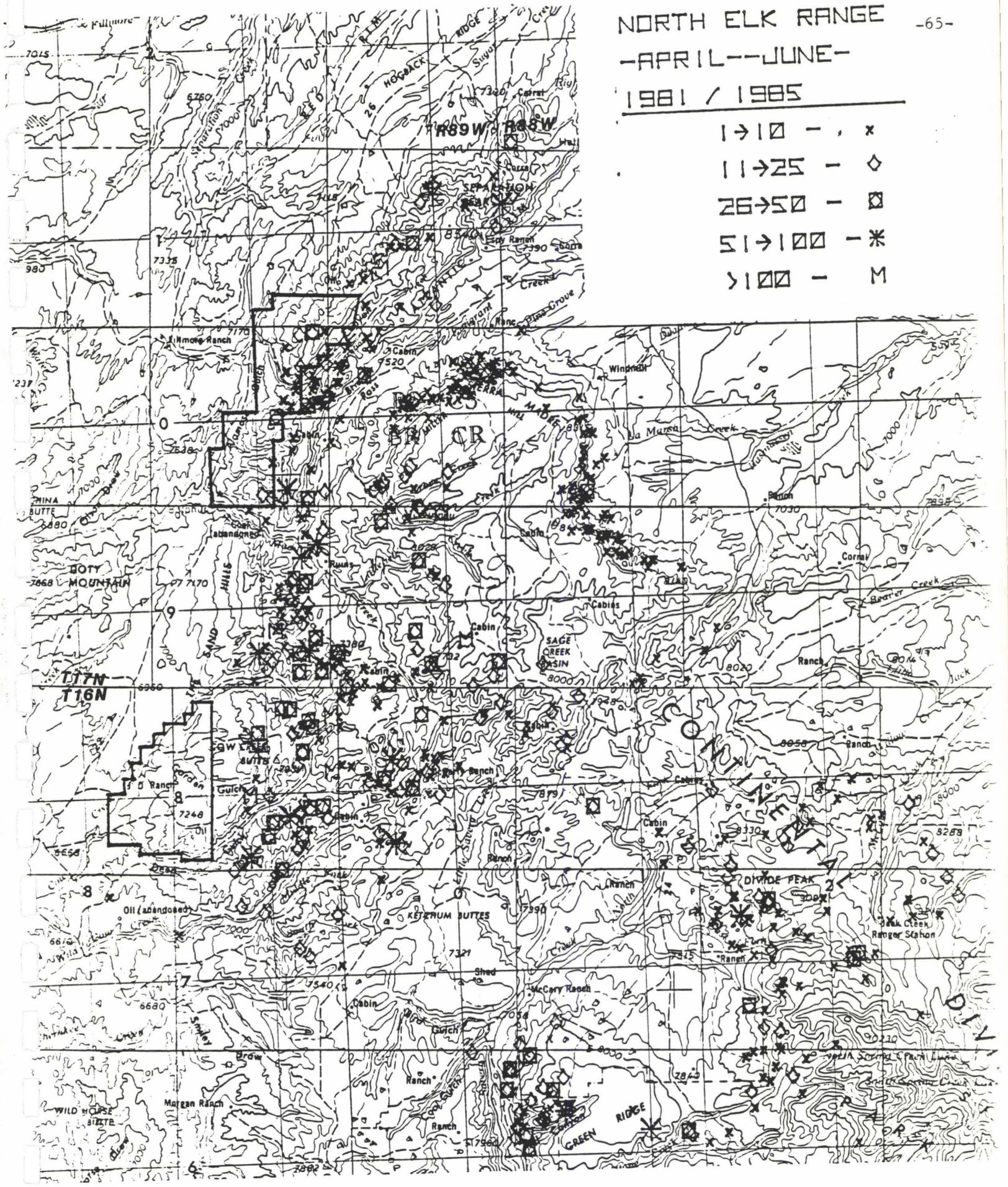

Figure 19. Elk seen on the north end of the KRCRA spring range, 1981-85.

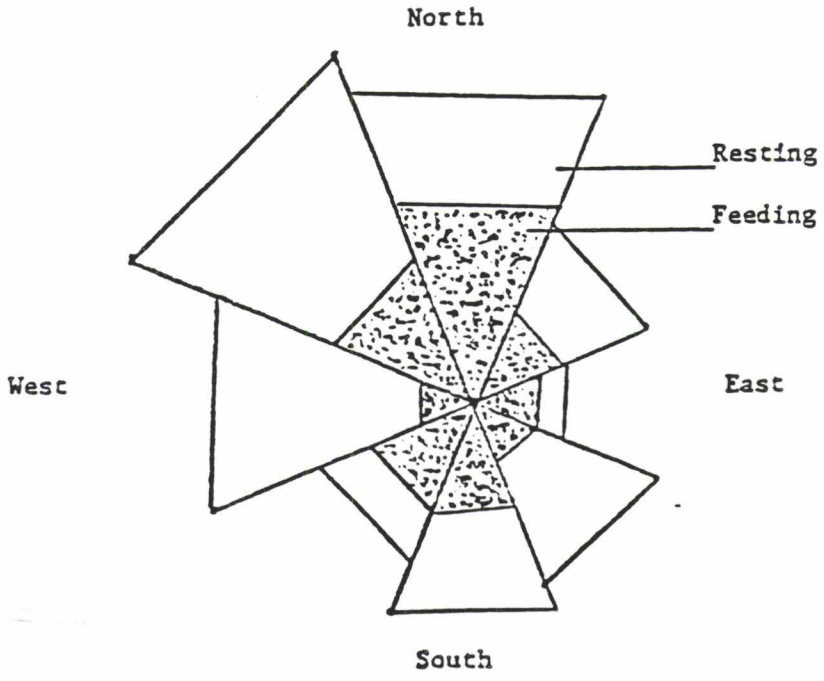

Figure 20. Percentages of elk use in relation to aspect for feeding and resting by the resident elk on the north end of the KRCRA during spring.

Elk stayed out on the open hills until the weather warmed up and shade was available. During June, they moved into areas with aspen stands for shade and better hiding cover.

The resident elk used habitat in common with domestic livestock, mule deer, and wild horses. The times located and the number of elk seen in relation to other animals were as follows:

	#Locations/#Elk seen (cumulative)			
Distance	Mule deer	Wild horses	Cattle	Sheep
≤ 25 yds	4/ 15			
≤ 50 yds	8/ 391			
≤100 yds	11/ 404		2/ 0	
≤200 yds	21/ 427		4/ 0	
≤1/4 mi	63/ 508	1/ 0	16/ 26	
≤1/2 mi	79/ 539	11/ 183	22/ 58	
≤ 1 mi	95/ 631	28/ 404	45/ 79	7/ 13
> 1 mi	107/1,498	171/1,618	163/1,952	192/2,009

Deer and wild horses occupied the spring elk range during the entire period. The elk and deer moved into the aspen type habitat at about the same time so the instances of close association increased in June. The elk moved to different habitat than the wild horses, which stayed on the sagebrush sites, so their associations decreased. Other domestic livestock came on the range in mid-May and did not immediately move into the aspen habitat, so the instances of close encounters with elk were relatively minor. Where cattle did move into areas occupied by elk, there was no indication that the elk were being displaced. The cattle in this area are in fenced pasture so there is little human activity around them.

The domestic sheep are herded so some response from elk was expected. The sheep herds were only in McCarty Canyon and at the top of Miller Hill in poor elk habitat so there was no direct pressure on any elk.

Elk locations in relation to human activity were as follows:

	#Locations/ #elk (cumulative)	
Distance	Traffic	Pedestrians
<100 yds	5/ 11	4/ 57
<200 yds	10/ 22	4/ 57
<1/4 mi	29/ 54	7/ 61
<1/2 mi	55/ 70	8/ 61
≤ 1 mi	63/ 106	9/ 61
> 1 mi	141/1,625	74/1,690

Traffic is very light on the unimproved roads throughout the spring because of muddy conditions. Most of the instances recorded where elk were within 0.25 mile of traffic or pedestrians were a result of research personnel activities. Elk were either in aspen or within 100 yards of aspen when the encounters within 1 mile were recorded, except for 4 elk that ran across an unimproved road in front of a moving vehicle. There was little human activity in the area during the aircraft searches in April, May and the first part of June.

There are many miles of road in the area. The roads are all dirt and unimproved, except for the county road over Bridger Pass and the 20-mile road west of Atlantic Rim that are graded. The road along the very east side of the area, going from Rawlins to the Forest, is hard-top.

During the calving period from May 20 to June 10 the resident elk on the north end of the KRCRA showed a strong tendency to use habitat at least 0.5 mile from roads whether or not the roads were used. Because most of the roads are located in the bottoms or along ridges where there is open terrain and no trees, it decreased the possibility of conflict with elk. The elk locations in relation to roads on the north end were as follows:

Distance	#Locations/#elk seen (cumulative) Roads
≥100 yds	1/ 2
≥200 yds	2/ 2
≥1/4 mi	4/ 6
≥1/2 mi	10/ 11
≥ 1 mi	23/ 36
< 1 mi	139/372

North end Migrant Elk

The data for the migrant elk using the north end of the KRCRA was based upon the locations of 32 telemetered elk and their associates. They were found 629 times and a total of 6,202 elk were seen in 219 different groups with an average of 28 elk per sighting. These elk started moving off the winter range in April or May, depending upon whether the spring was early or late. Their dispersal was in 2 main directions in about equal numbers, either to Divide and Dexter Peak in the east or to the Savery River Canyon in the southeast (Figure 18). Telemetry showed that these elk may go one way and come back another when moving between winter and summer range.

Elk use in relation to aspect is shown in Figure 21. They showed no significant difference between feeding and resting with respect to aspect and slope. Elk were found 73 percent of the time on slopes of less than 20 percent, and 77 percent of the time they used southerly or westerly facing slopes.

Herds with both feeding and resting elk were seen at 9 percent of the locations. The elk were either feeding or resting in sagebrush/grass over 50 percent of the time and most of these sightings occurred in April before they moved off the winter range. They were found in mountain shrub about 12 percent of the time, which occurred mainly on the south or west slopes of Hells Canyon, and Little and Big Sandstone Creek in the Green Ridge area. They were found in aspen 10 percent and lodgepole pine 15 percent of the time. This use occurred after they moved to the forested area in mid-May and June.

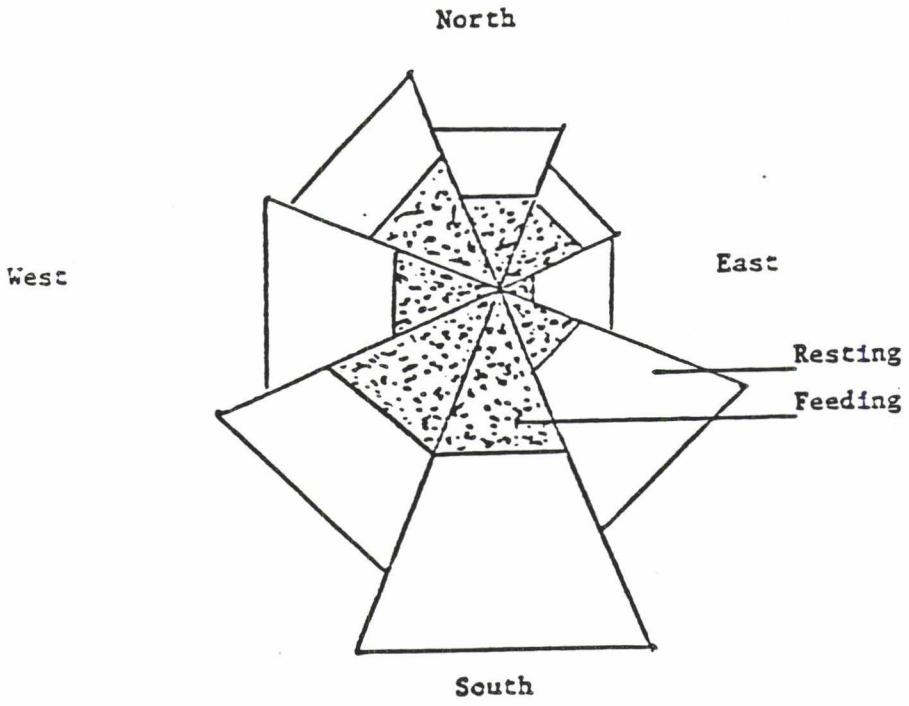

Figure 21. Percentages of elk use in relation to aspect for feeding and resting by migrant and resident elk on the north end of the KRCRA during spring.

During the calving season the elk were found 33 percent of the time in sagebrush, 40 percent in aspen, 13 percent in lodgepole pine and aspen, and 10 percent in mountain shrub.

Feeding and resting migrant elk from the north end of the KRCRA located various distances from tree cover during spring were as follows:

	#Locations/#Elk (cumulative)	
Distance	Feeding	Resting
≤ 25 yds	228/ 554	185/ 339
≤ 50 yds	331/1,287	197/ 529
≤100 yds	408/1,833	209/ 643
≤200 yds	480/2,414	227/ 905
≤1/4 mi	608/3,918	305/1,657
≤1/2 mi	691/5,556	369/2,528
≤ 1 mi	726/6,079	394/2,756
> 1 mi	420/9,222	

The elk stayed on the open sagebrush hillsides until the weather warmed up in late April. They then began moving to the forested areas and by June most were on the National Forest where there are coniferous trees.

By the time elk had moved to the forested areas the weather was warmer and elk were using the trees for thermal and hiding cover. Human activity in most of the area is very light due to muddy road conditions, so thermal cover is probably the most important function of the trees this time of year.

The migrant elk on the north end of the KRCRA share habitat with mule deer, wild horses, and domestic livestock. The times located and the number of elk seen in relation to other animals were as follows:

Distance	#Location/#elk (cumulative) Mule deer	Wild horses	Cattle
≤ 25 yds	1/ 8		
≤ 50 yds	6/569		
≤100 yds	10/582		2
≤200 yds	28/609		3
≤1/4 mi	113/887	4/ 60	1/ 19
≤1/2 mi	143/972	16/310	2/ 70
≤ 1 mi	196/227	54/816	5/ 154
> 1 mi	433/975	575/386	579/6,048

Mule deer are difficult to see from an airplane even on winter range, so their sightings should be considered conservative. Also, the deer population was reduced after the severe winter of 1983-84, which further lessened the chance of seeing them. Elk and deer do use the same areas during the spring.

The wild horses do not move with the migrant elk so their association decreases when the elk leave. The major range overlap takes place in April and early May in the Cow Creek Complex area. It also occurred on Atlantic Rim and Miller Hill until the horses were trapped and removed. Horses are slowly returning, however.

The association with cattle occurs mainly in the Divide Peak and Green Ridge area after the cattle are released in June. Many times the elk were located from the airplane in tree cover and the cattle were seen in adjacent sagebrush or grassland. Our data is conservative because it was not possible to see the cattle in the trees where they could have been closer to the telemetered elk.

There is some chance for error in judging the effects of the introduction of cattle on elk range. The first problem is knowing where the people are that bring in the cattle. Elk are affected more by people than cattle (Ward and Cupal 1979). The second problem is trying to determine if the elk are still migrating when the cattle are released and therefore if the elk movements are natural and not caused by cattle. Both situations have been observed on this range. When human disturbance is not a factor and only resident elk are considered, there is little evidence to suggest that the elk are socially incompatible with cattle.

Elk locations in relation to human activity were as follows:

	#Sightings/#elk seen (cumulative)	
Distance	Traffic	Pedestrians
≤100 yds	0/ 0	0/ 0
≤200 yds	1/ 0	0/ 0
≤1/4 mi	5/ 6	2/ 2
≤1/2 mi	8/ 9	4/ 2
≤ 1 mi	32/ 29	7/ 3
> 1 mi	597/6,173	622/6,199

Only 8 times, involving 9 animals, were elk found within 0.5 mile of traffic. In 95 percent of all cases elk were over a mile away from traffic. They showed even stronger response to stay away from people walking. Most of the closer encounters with pedestrians and traffic occurred in June after the roads became passable.

As the elk migrate to the forest, especially in the Divide and Dexter Peak area, they cross the Rawlins to Sandstone Ranger Station road which is the main access to the public and private lands. Other arterial roads such as the McCarty Canyon, Tullis, Green Ridge, and Jack Creek roads account for several miles of dirt roads in the area. During wet years many of these roads are too muddy or have snow drifts that prohibit travel until early June. They were passable in early May during the dry year of 1981.

Elk locations and sightings in relation to roads during the calving season between May 20 and June 10 were as follows:

Distance	#Location/#elk seen (cumulative)
≤100 yds	0/ 0
≤200 yds	1/ 0
≤1/4 mi	10/ 7
≤1/2 mi	18/ 21
≤ 1 mi	33/ 50
> 1 mi	205/519

It was quite evident the elk preferred calving areas over a mile from roads whether or not the roads were being used. There were areas in Jack Creek and on Green Ridge where 9 percent of the elk were located within 0.5 mi of a road and only 5 percent were within 0.25 mile. In every case these areas were screened from the road by trees.

Presently, there appears to be no conflict between the multiple uses in the area and elk migration or calving. No vehicle-elk accidents have been reported and the elk migration has not been diverted or disrupted. Human activity has generally been very light and confined to major gravel roads until the first week of June or later.

The human activity on the KRCRA of Atlantic Rim and the Cow Creek Complex mainly begins in May with the introduction of livestock. Since the migrant elk move off this area before the livestock come on there are no major conflicts. Controlled access to much of the land in the Miller Hill area keeps most people out.

The new road built from Deep Creek around Dexter Peak into the Jack Creek drainage on the National Forest passes through an area southwest of Dexter Peak used for calving. Most of the calving area, however, is below the road which is mainly above 8,500 feet in elevation. The heavily used parts of the calving area are either on private land or below the road. No construction or traffic has occurred on this road during the course of the study when elk were calving in the area. The wet soil conditions prevented construction for the last 2 years. After the main road is completed it would be advisable to keep this road closed to traffic until after the elk calving season. With normal snowpack and the regular spring seasons, the ground near the road would be too wet for logging or recreation, and a closure would assure that the elk were not bothered during calving.

South end of KRCRA

The elk using the spring range on the south end of the KRCRA start moving off their winter range as soon as the snow melts and the southerly facing slopes begin producing green foliage. Usually they start moving in April, but during the heavy snow year of 1984 the elk moved in May. Their major routes are up the Battle Creek drainage, with some animals going

north and higher to Green Ridge. The telemetered elk from the winter range in Colorado either come back into Wyoming and then move east or go directly east in Colorado. The major road crossing is in the Horse and Battle Mountain area.

During the study, 38 telemetered elk and their associates were followed on their spring range. Two cows were followed for 4 years, 3 cows for 3 years, 5 cows for 2 years, and the remainder for 1 year. They were found 801 times and 11,861 elk were seen in 681 groups with an average of 17 elk per group Figure 22.

The elk use in relation to aspect is shown in Figure 23. They showed no significant difference between feeding and resting with respect to aspect and slope. Seventy-five percent of the time the elk were on slopes less than 20 percent, and 73 percent of the elk used southerly or westerly facing slopes.

The elk were found feeding or resting in the following types of habitat:

Type	Percent feeding	Percent resting	Percent feed and rest
Sagebrush	45	37	61
Mountain shrub	35	42	28
Riparian	2	2	1
Aspen	20	13	9
Lodgepole pine-Aspen	3	4	0
Other	1	1	1

Sagebrush and mountain shrub were the preferred habitats for both feeding and resting, especially during April and May. As the season progressed into June, the elk showed more use of aspen and the aspen-lodgepole pine types.

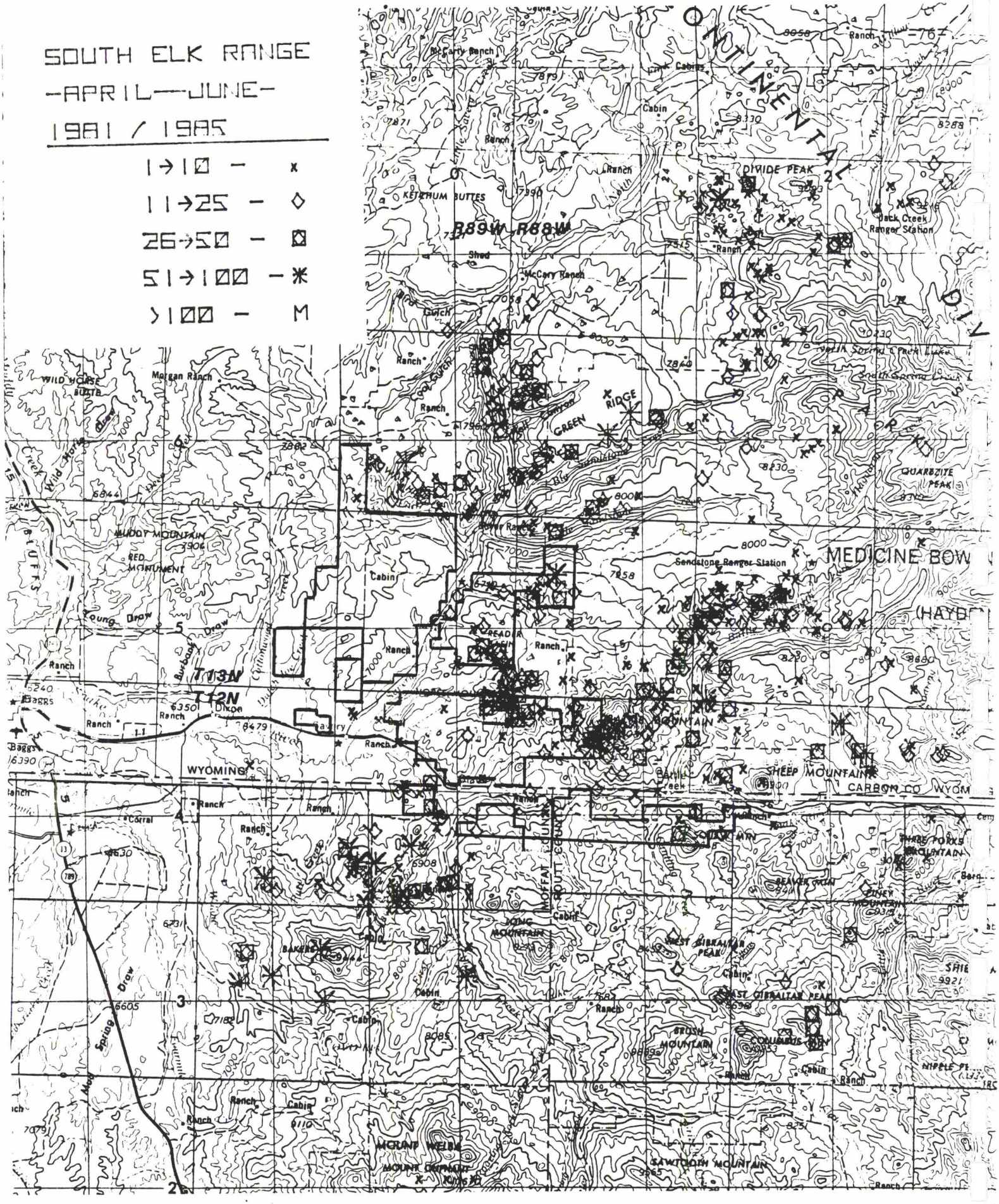

Figure 22. Elk seen on the south end of the KRCRA spring range 1981-85.

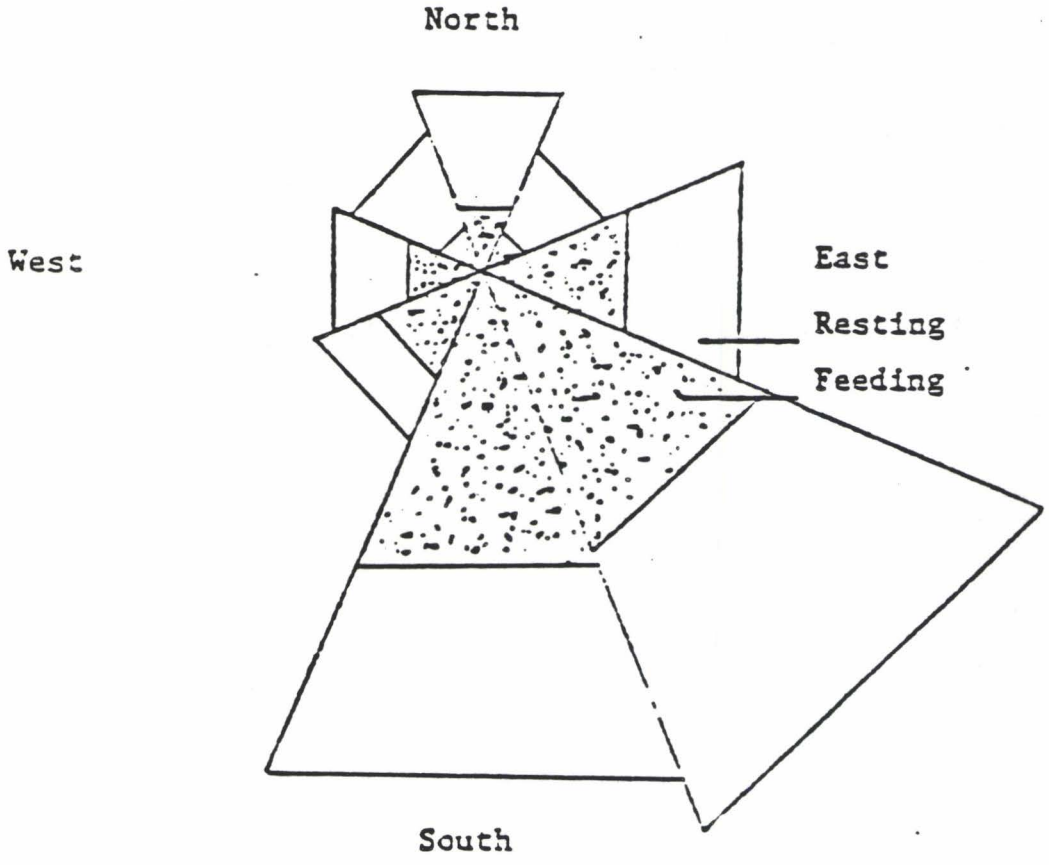

Figure 23. Percentages of elk use in relation to aspect for feeding and resting by all elk on the south end of the KRCRA during spring.

Elk on the south end of the KRCRA use habitat occupied by mule deer and domestic livestock during the spring. The number of times located and the number of elk seen at various distances from other animals were as follows:

	#Locations/# elk seen (cumulative)			
Distances	Mule deer	Cattle	Sheep	Horses
≤25 yds	1/ 10	1/ 1	1/ 1	
≤50 yds	8/ 206	1/ 1	2/ 50	
≤100 yds	15/ 293	1/ 1	2/ 50	
≤200 yds	32/ 491	1/ 1	2/ 50	
≤1/4 mi	160/2,741	18/ 138	5/ 103	5/ 25
≤1/2 mi	209/3,388	30/ 211	11/ 147	12/ 37
≤ 1 mi	256/3,940	63/ 553	17/ 167	17/ 50
> 1 mi	344/8,021	537/11,408	583/11,794	83/11,911

Mule deer are very common, but difficult to see from an airplane. There were undoubtedly more close associations between these 2 species than recorded. No social problems were noted even though there is overlap in the areas of use.

There were several close associations with domestic livestock during April and May of 1984 due to the late spring. Elk and cattle were seen in close association with each other during June in the Circle Mountain area of Colorado.

Elk locations in relation to human activity were as follows:

	#Locations/#elk seen (cumulative)	
Distance	Traffic	Pedestrians
≤100 yds	1/ 4	-
≤200 yds	1/ 4	1/ 1
≤1/4 mi	15/ 68	2/ 1
≤1/2 mi	33/ 203	5/ 14
≤ 1 mi	89/1,095	11/ 98
> 1 mi	511/11,863	689/11,863

During the spring 90 percent of the elk located by radio collar or seen along the Little Snake River were at least a mile from traffic. At least 99 percent of the elk were more than a mile from people walking. These

counts do not include the human activity associated with the elk feedlines along the Little Snake River or in Colorado during the spring of 1984.

Elk locations and sightings in relation to roads during the calving season between May 20 and June 10 were as follows:

	#Locations/#elk seen (cumulative)
Distance	Roads
≤1/4 mi	5/ 13
≤1/2 mi	7/ 21
≤ 1 mi	18/ 27
> 1 mi	183/1,212

During the calving season 90 percent of the elk stayed over a mile from roads. Only the major graveled roads are passable from May 20 to June 10 and the major calving areas are over a mile from these roads. Very few elk stay within the KRCRA on the south end during the calving season so there would be no direct conflict with proposed coal mining.

Independence Ridge

In the Independence Ridge area near Big Creek, on the east side of the Continental Divide, 8 telemetered elk have been followed through 2 spring seasons. They were located 143 times and 192 elk were seen in 11 different groups for an average of 17 elk per group.

From the limited available information there was no significant difference shown by the elk for feeding or resting in relation to aspect or slope. The drainages slope to the east in this area and about 90 percent of the elk locations were on northeast to south facing slope (Figure 24). Elk were found on slopes of less than 20 percent at least 71 percent of the time.

Twelve percent of the resting elk and 3 percent of the feeding elk were located in coniferous trees on Independence Ridge. Aspen mixed with sagebrush and some mountain shrub make up the majority of the habitat on this spring range and the elk were found using these areas for both feeding and resting most of the time.

During the calving season from May 20 to June 10, these elk were found 54 percent in aspen, 21 percent in conifer, 20 percent in sagebrush, and 5 percent of the time in meadows.

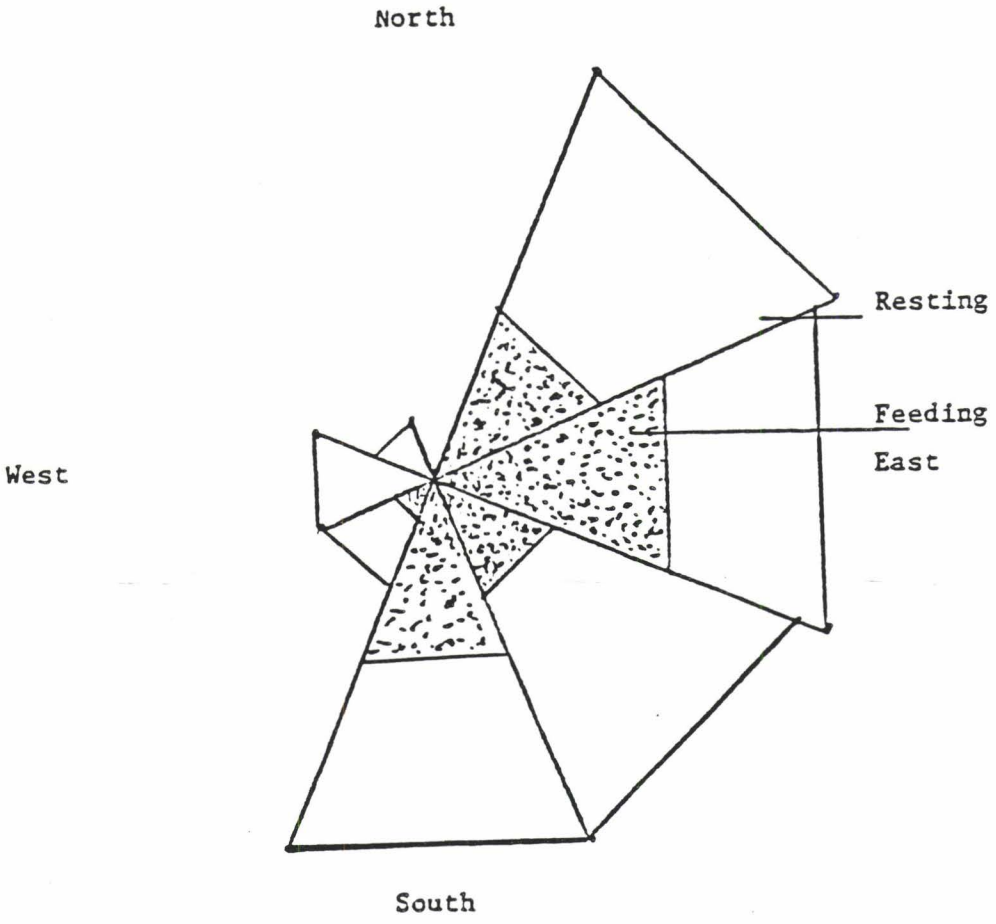

Figure 24. Percentages of elk use in relation to aspect for feeding and resting by elk in the Big Creek area during spring.

There are no passable roads in this area until about mid-June so no traffic or pedestrians were seen within a mile of elk. By the time traffic can get into the area the elk have started to leave their winter range.

The elk move from their winter range in various directions, following the snow melt and plant development to higher elevations. A couple of the bulls, however, have stayed on Independence Ridge until late June or July. The cows moved to the west toward Blackhall Mountain and Big Creek Lakes. The bulls have shown wider and less predictable travels. For example, 2 bulls moved south into Colorado to Lone Pine Creek. One bull moved up to Three Island Lake and the other traveled northwest over the Continental Divide to Shield Mountain.

Spring Migration

In order to monitor the migration routes of the northern elk herd from their winter range to summer range, a systematic count of elk tracks was conducted on selected roads. These counts usually encompassed about a 4 week period during all 5 years of the study. The information from the counts, presented in Figure 25, was used to supplement the telemetry data and the observations from aircraft. Since many of the radio-collared elk migrate from Deep Gulch ridge or Rendle Rim to the National Forest in less than 36 hours, it was difficult to pin-point precise migration corridors by using only radio-telemetry.

The arrows with tails in Figure 24 depict migration routes as determined by telemetry and observations. Arrows without tails refer to 5 composite years of track count data as a relative index with respect to abundance and frequency. Small arrow depicts less than 10 elk.

Migration initiation dates were related to snowmelt and vegetation green-up which varied among years. Our techniques showed that the elk exhibit some predictable preference for migration corridors, but the elk are wide ranging. Track counts through McCarty Canyon, at Ketchum Buttes and west of Divide Peak, were consistently high. The Grizzly Ranch area was high only in 1985. Some of the twelve telemetered elk monitored for more than a year varied their spring migration routes. In fact, Cow 15 and Cow 58 would migrate in the spring of one year and not until fall of another year.

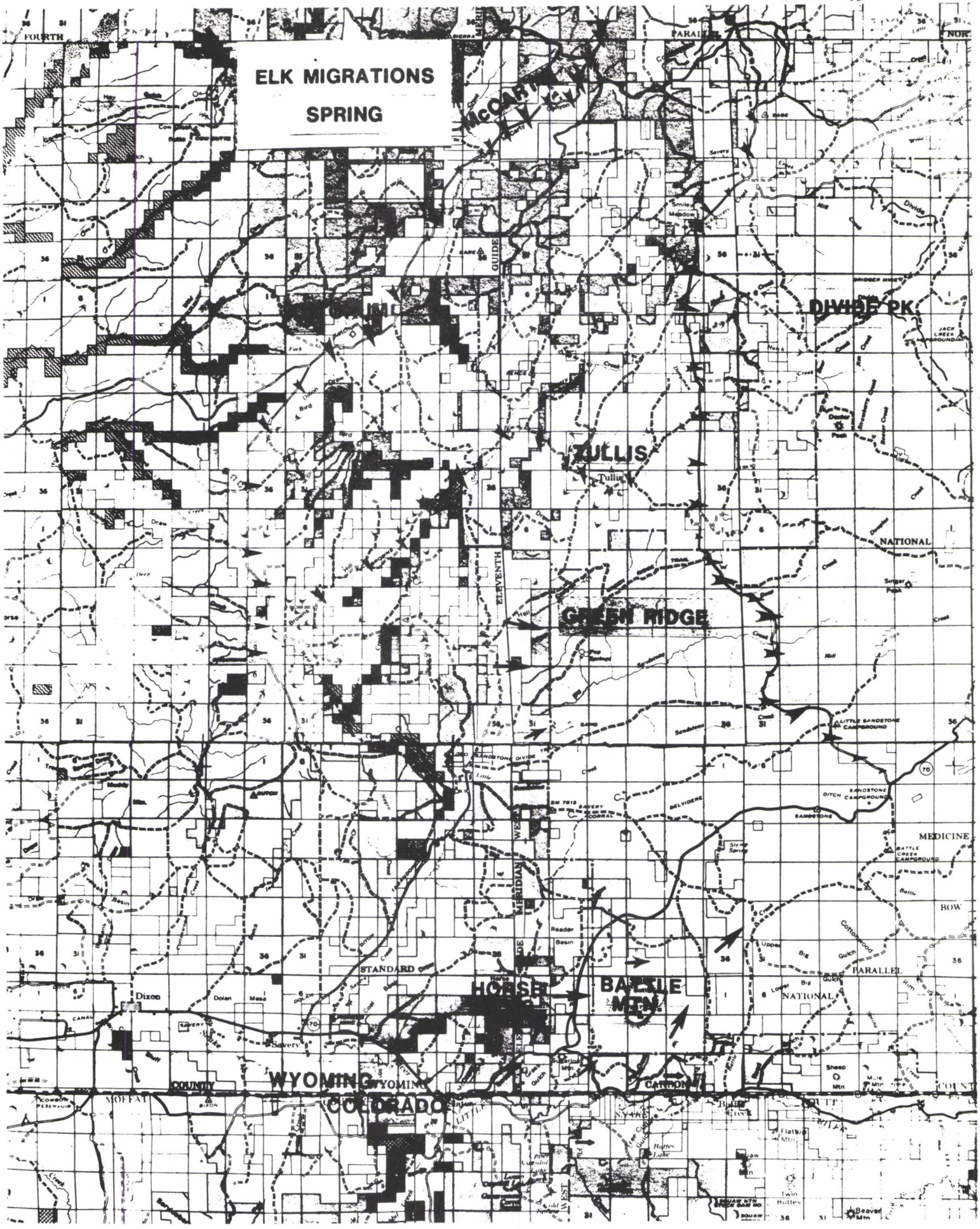

Figure 25. Spring elk migration routes.

Elk migrations on the south end showed a consistent trend throughout the study. Individual telemetered elk did not make rapid movements of great distances as opposed to elk on the north end. The majority of the herd gradually moved across the south side of Battle Mountain and then upwards through the Battle Creek drainage. Others moved into the Battle Creek drainage via the north slope of Battle Mountain or northeastward from Horse Mountain into the Sandstone drainages. Most of the elk from Fan Rocks in Colorado and few of the Horse Mountain elk migrate up the Little Snake River drainage. The Colorado elk migrate south of the river corridor toward Three Forks and Shield Mountains.

Calving Area Fidelity

Cow (31) was tracked during 4 calving seasons. She was a yearling the first year (1981) so probably did not have a calf that year. During the next 3 calving seasons she returned to the same general area of Dexter and Divide Peaks and Jack Creek Knoll. There was no indication that she used the same specific area to have her calf each year.

Three mature cows (22, 12, and 15) were tracked through 3 calving seasons. Cow 22 spent the 1982 calving season in the Fletcher Peak area. In 1983 she used an area on the north end of Cottonwood Rim about 4 miles west of Fletcher Peak but in similar habitat. She spent the 1983-84 winter on the east side of the Continental Divide and was on the west side of the Encampment River at Dunkard Creek during the 1984 calving season. This area is at least 14 airline miles east of her 2 previous years' calving areas.

Cow 12 was a resident of the winter range at Atlantic Rim and Miller Hill. She had her calf in 1981 and 1982 on the northwest side of Eagle Ridge, which is on the northwest side of Miller Hill. For some unknown reason she had her calf on the west facing drainage of the east ridge of Separation Creek on Atlantic Rim in 1983. The 2 areas are about 3 miles apart, but the aspen and sagebrush habitat is similar.

Cow 15 spent the winters in the Cow Creek, Muddy Creek and Atlantic Rim area and in 1982 moved to the Dexter Peak area on the Forest during the calving season. In 1983 she stayed and had twins in Cabin Draw in the upper Muddy Creek drainage. She used this same area during the calving season of 1984.

The 14 cows tracked during the calving season for 2 years showed some fidelity to general calving areas. The 7 cows (7, 42, 44, 47, 50, 53, and 56) from the north end of the winter range moved in several directions. Cow 56 stayed on the winter range at the head of Separation Creek and Beckman Creek on the north end of Atlantic Rim in 1983 and 1984. Cows 7, 44, 50, and 53 were found in the same general areas of Divide Peak, Jack Creek, and Dexter Peak in both years. Cows 67 and 42 used Green Ridge north of Big Sandstone, and Battle Creek east of the Sandstone Ranger Station, respectively, and returned to these same areas both years.

The 7 cows (10, 11, 26, 27, 32, 35, and 41) from the south end of the winter range went in different directions for calving. Cows 27 and 41 consistently used the area around Circle Mountain in Colorado. Both cows 26 and 35 used the east slopes of Three Forks Peak in Colorado in 1984, but cow 26 spent the calving season on Cottonwood Rim and Fletcher Peak in 1983. Cow 32 moved up Battle Creek in 1982 and stayed just east of the Forks during the calving season. In 1983, she was found on Three Forks Peak on May 31, then moved to Battle Creek at the north end of Cottonwood Rim by June 8 and was still in this area on June 14. These 2 areas are in similar habitat, but about 2 miles apart. Cow 10 also wintered on the east side of the Continental Divide in 1983-84. She spent the 1983 calving season in the Stemp Springs and Circle Bar area on the north side of Battle Creek. The last signal was received from Cow 10's radio in the North Fork of the Encampment River about 18 miles to the east of Stemp Springs at the start of the 1984 calving season. Cow 11 spent 1982 on Green Ridge south of Little Sandstone Creek during the calving period, and moved to higher elevation at Willow Peak in July. On May 31,1983 she was south of the Sandstone Ranger Station but moved over the Continental Divide to Cow Creek by June 8. She then moved south to arrive at Willow Peak by mid-July. She winterkilled on the Colorado Division of Wildlife feedline in February 1984. Her teeth annali showed that she was 14.5 years old.

The data from the cows from the KRCRA winter range show a moderate fidelity for repeated use of calving sites. It also shows a wide variation in altitude and habitat components of calving areas. Four consistent habitat characteristics were available in all areas, namely: food, thermal cover from cold (insolation), thermal cover from heat (shade), and hiding cover (aspen and conifer trees). The altitudes used depended on snow depth

and runoff at calving time and varied from 7,500 to 9,000 feet. In 1984 the elk were slow in moving to the higher elevations due to the unusually heavy snow. The deep snows caused a late melt off and delayed vegetation development in spring.

The vegetation on most of the calving sites, particularly at the lower elevations, was aspen-sagebrush. At the higher elevations calving sites included sagebrush-mountain shrubs-aspen and lodgepole pine.

Summer Elk Distribution

All Migrant elk

The distribution and travels of the telemetered migrant elk and their associates from May to August, 1981 to 1984, are shown in Figure 26. This includes the 25 telemetered elk from the north end, 23 from the south end, and 6 from Independence Ridge. The greatest overlap in elk distribution from the north and south end of the KRCRA occurs during the summer in the Standard and Huston Park Wilderness area. Six elk (24 percent) captured on the north end spent part of the summer in the wilderness area with the 14 (60 percent) telemetered elk from the south end. Two elk (cow 13 and spike 5) came down the east side of the range from Divide Peak to overlap with elk both from Independence Ridge and the south end of the KRCRA. One bull from Independence Ridge spent the summer on the east side of Shield Mountain with elk from the south end of the KRCRA.

There is enough interchange of migrant elk on the summer range from the 3 major winter ranges to justify treating these elk as one large herd, particularly the elk from the KRCRA. One bull (16) trapped on Divide Peak in May 1981 spent the winter of 1981-82 on the south end of the KRCRA. Two cows (10 and 22) trapped on Horse Mountain spent the winter of 1983-84 on the east side of the Continental Divide.

During the 4 summers 763 elk locations were made and 3,441 elk were seen in 187 groups for an average of 18 elk per group. The location of elk in relation to aspect for feeding and resting is shown in Figure 27. There was no significant difference in relation to aspect and slope for herds with both feeding and resting elk. Since most of the elk stayed in drainages that sloped to the west, 70 percent of the locations were in the northwesterly to southeasterly aspect. About 80 percent of the locations were

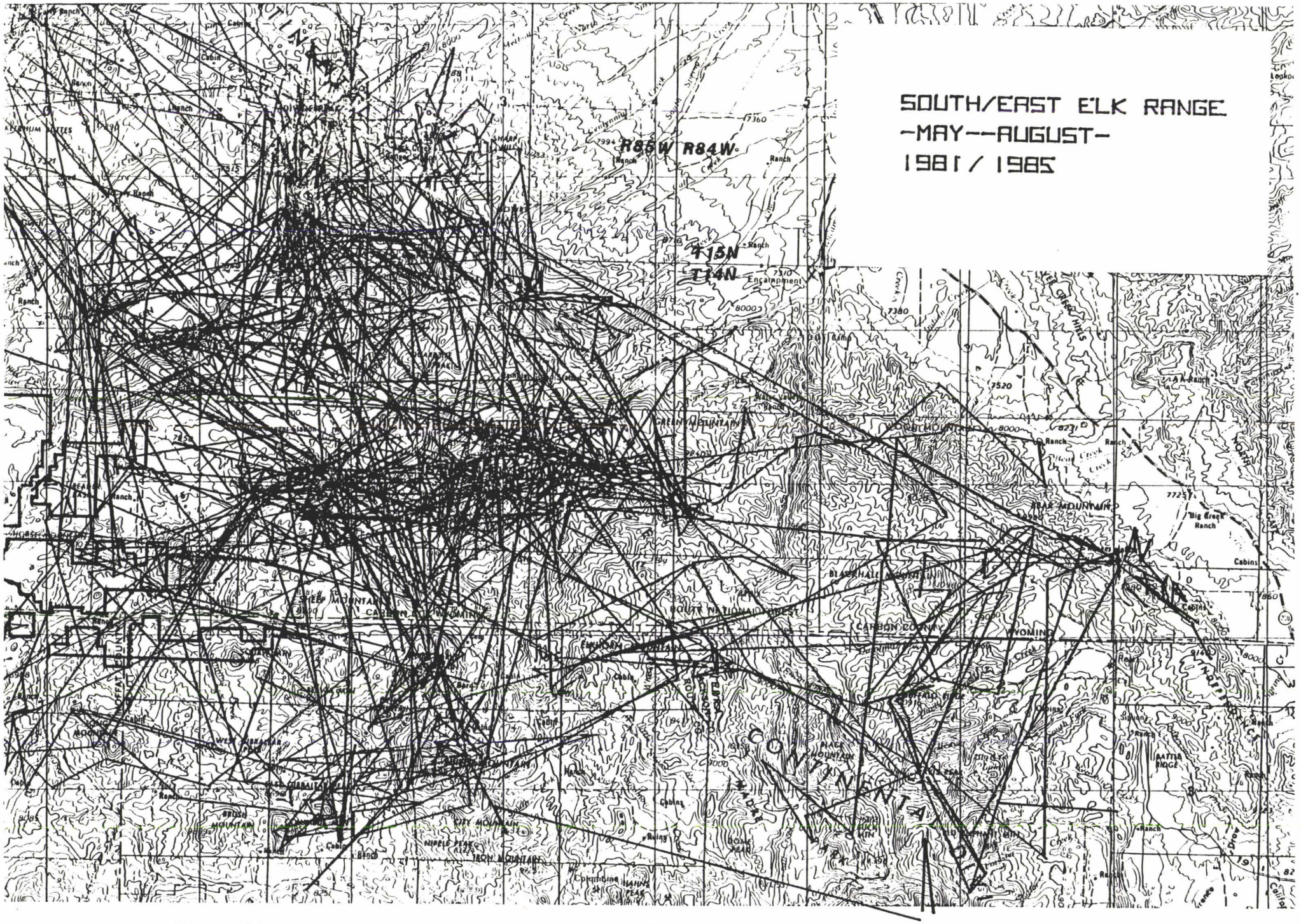

Figure 26. Summer movements of 73 telemetered elk, 1981-85.

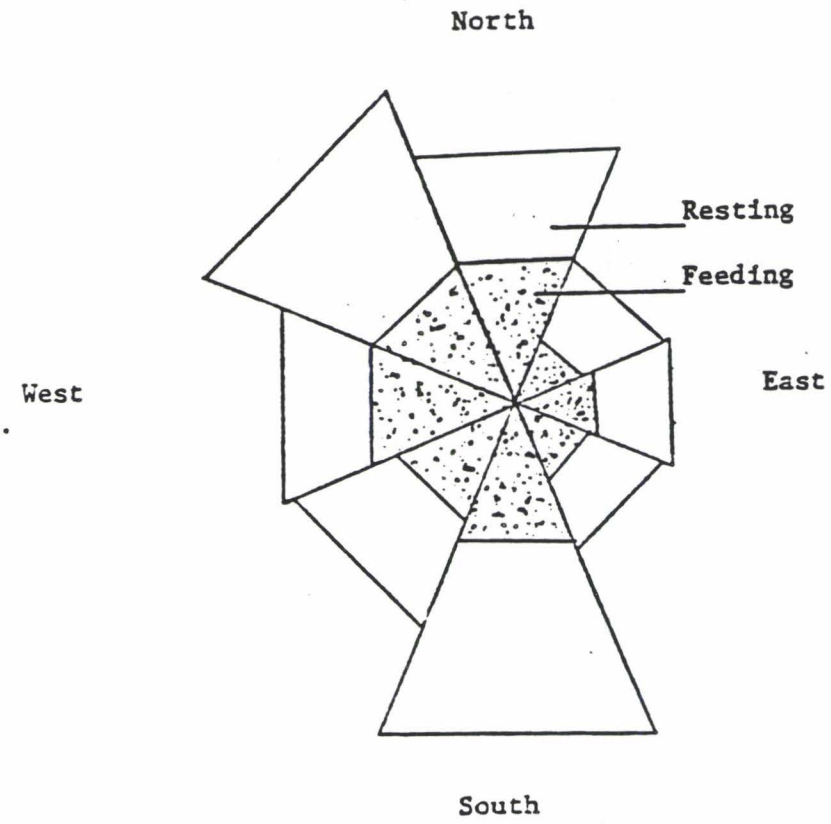

Figure 27. Percentages of elk use in relation to aspect for feeding and resting by all migrant elk on the KRCRA during summer.

on slopes of less than 20 percent. The use on steeper slopes occurred in the canyons at the mid-elevations. Because the migrant elk on the summer range were scattered from lower elevations of 8,000 feet to above timberline over 11,000 feet, they had a large number of habitat types to use.

The percentages of locations for known feeding and resting elk in relation to habitat types were as follows:

	Number of Sightings		
	403	242	53
	Percentage of Sightings		
Habitat type	Feeding	Resting	Feeding and Resting
Alpine	2	4	9
Spruce-Fir	26	27	32
Lodgepole pine-Aspen	26	38	26
Clearcuts	1	0	0
Aspen	15	13	4
Riparian-Meadows	16	10	25
Mountain shrub	5	7	2
Sagebrush	8	0	2
Other	1	1	0

Elk in the alpine did not have trees available for shade or hiding. Five of the 23 alpine sightings had both feeding and resting elk present. No people were seen near these elk, so hiding cover was not necessary and the cooler temperatures and wind provided the thermal cover requirements.

Elk in the spruce-fir were mainly using the subalpine areas along the Continental Divide, especially the wilderness area of Standard and Huston Parks, and Bridger and Valcan Mountains. These tree stands are made up of large trees with openings where elk forage. There is very little human activity in these areas during the summer.

Lodgepole pine intermixed with aspen make up the largest portion of the habitat on the summer range. No attempt was made from the airplane to separate pure stands of pine from those having some aspen present. A high percentage of resting elk was found in this type, probably because there is a lot of it and lodgepole pine-aspen does provide good thermal and hiding cover.

Elk were seen feeding in clearcuts on Green Ridge and in the Divide Peak and Jack Creek areas. When observed from an airplane early in the morning they were usually seen feeding in the shade of trees.

Riparian areas and meadows were combined because they included a wide assortment of sites such as stream bottoms, beaver ponds with willow and aspen, and higher elevation meadows. They all have a high soil moisture level, good elk foods, and available cover. Both feeding and resting elk were often seen using these sites, particularly at the higher elevations and at least a mile from human activity.

Elk used the sagebrush habitat mainly for feeding during the summer. Frequently, the elk feeding in sagebrush stayed near either mountain shrub or aspen.

The migrant elk use the summer range along with other ruminants. Locations of elk and distances from other animals were as follows:

	#Locations/#elk seen (cumulative)	
Distance	Mule deer	Cattle
≤100 yds	2/ 6	5/ 35
≤200 yds	8/ 6	20/ 133
≤1/4 mi	87/245	112/ 337
≤1/2 mi	95/266	165/ 415
≤ 1 mi	103/270	244/ 779
> 1 mi	180/900	519/2,662

Mule deer occupy most of the elk summer range. The low numbers of close associations is a reflection of the difficulty in seeing deer from the airplane. No telemetered deer were being monitored, and the tree cover on the summer range made it impossible to determine how close many deer were to the elk. Few deer used the high elevation alpine meadows. In other areas deer and elk used the same habitat.

Cattle grazed within the summer range of only 24 (44 percent) of the telemetered elk. The greatest overlap occurred at Divide Peak, Green Ridge, Battle Creek, and in Colorado around Circle, Shield, and Elkhorn Mountains. The greatest number of sightings of cattle near elk occurred in the Circle Mountain area where both elk and cattle are relatively abundant and easy to see from an airplane. Two telemetered cows (27 and 41) and

their associates used this area for 2 summers and there was no indication that the elk were being moved by the cattle. The area is fenced and protected from public access by private land, so the only human disturbance is associated with cattle management.

The few bands of domestic sheep using the range were herded and only 3 times were telemetered elk located within a mile of the sheep. The light use by sheep at the present time does not present a problem for the elk.

Elk locations in relation to human activity were as follows:

	#Locations/#elk seen (cumulative)		
Distance	Traffic	Pedestrians	Timber operations
≤100 yds	1/ 21		
≤200 yds	1/ 21		
≤1/4 mi	9/ 22	3/ 0	
≤1/2 mi	37/ 50	17/ 1	2/ 0
≤ 1 mi	67/ 66	37/ 5	4/ 0
> 1 mi	216/1,104	160/289	279/117

Over 90 percent of the locations of elk within a mile of human activity were involved with the 18 telemetered elk whose summer range included areas where roads were over a mile per section in density and either recreation or people working were present. Jack Creek, Green Ridge, Battle Creek, and Blackhall Mountain were 4 areas where elk and high human activity levels were both present. There were 2 notable areas with high human activity and low elk use. One was the mile corridor along the Sandstone road from Rawlins and Encampment, and the other was the Stage II water development operations, in both Hog Park and the water diversion area on the west side of the Continental Divide in the Little Snake River drainage.

There were low populations of elk on Green Ridge and the Divide Peak areas during the summers. However, this could be the result of good hunter access and high harvest in previous years rather than elk leaving the areas. The presence of some elk using the area would indicate that harvest

was the main reason for low elk numbers. The closing of roads and restrictions on harvest should result in more elk using the area in the future.

High concentrations of elk were noted in the more inaccessable areas at the head of Jack and Spring Creeks (on the north end) and in the wilderness areas of Standard and Huston Parks (in Wyoming) and the refuge areas protected by privately controlled access (in the Circle, Shield and Columbus Mountains area of Colorado). These elk are not only in remote areas during the summer, but stay in these same areas during the early part of hunting season where they avoid heavy hunting pressure.

North end resident elk

During the 4 summer seasons 8 telemetered elk and their associates were tracked on the north end of the KRCRA: 2 cows (12 and 15) for 3 years, and 1 spike (29) and 5 cows (3, 19, 56, 67, and 58) for 1 year. Elk have been located 109 times and 263 elk were seen in 30 groups with an average of 9 elk per group. The distribution and travels of these resident elk during the May to August period are shown in Figure 28.

The location of these elk in relation to aspect for feeding and resting is shown in Figure 29. They show no significant difference in aspect and slope between feeding and resting. About 90 percent of the sightings were on west to north facing slopes and 76 percent of the use was on slopes of less than 20 percent.

Resident elk concentrate their summer use in the Miller Hill, Atlantic Rim, and Rendle Butte area where aspen stands provide thermal and hiding cover. About 60 to 80 percent of the resident elk were found on the east and north side of Miller Hill where they are protected by controlled access. The 20 to 40 percent of the elk that stay in the area from Atlantic Rim south to Rendle Butte occupy the small aspen patches on the northwesterly facing slopes in the small draws. They move frequently, probably due to human disturbance, and are part of the herd that use Miller Hill. Telemetered cow 12 and some of her associates moved between Miller Hill and Atlantic Rim several times during the summers. Because cow 15 migrated to the Dexter Peak area during the summer of 1982 and staved in Cabin Draw and Rendle Butte during the summers of 1983 and 1984, the identification of resident or migrant elk in this area is not distinct.

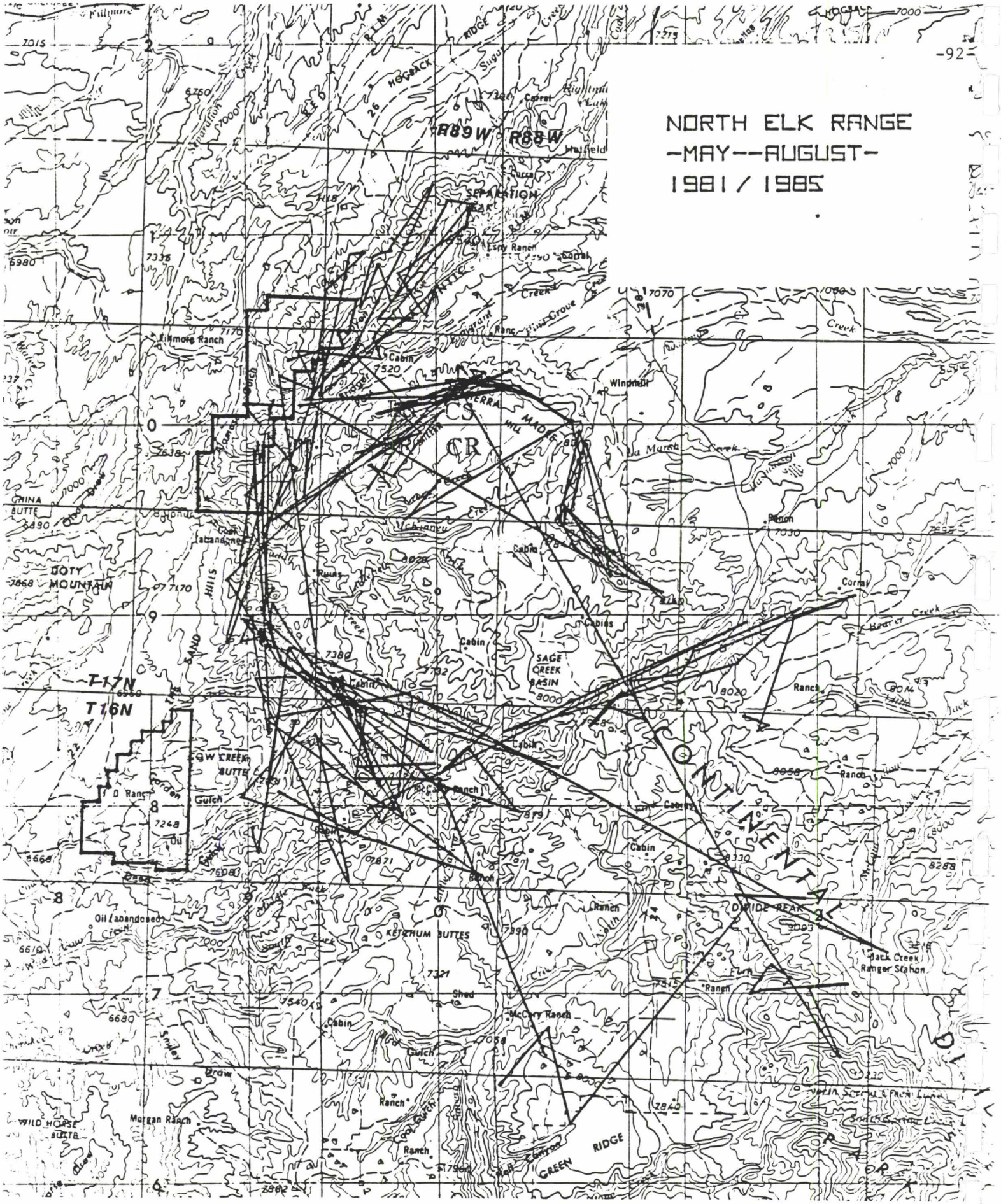

Figure 28. Summer movements of resident telemetered elk on the north end of the KRCRA, 1981-85.

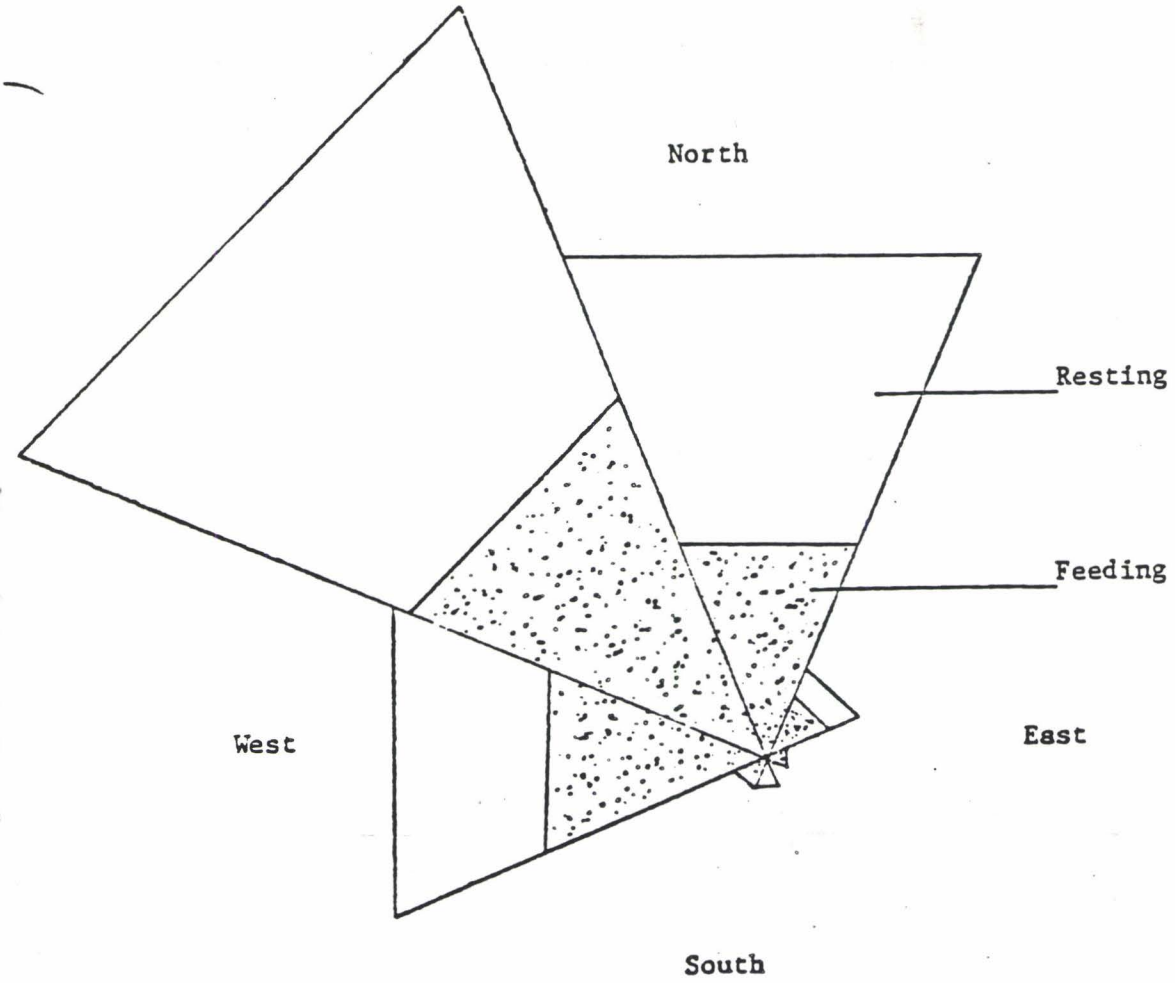

Figure 29. Percentages of elk use in relation to aspect for feeding and resting by resident elk on the north end of the KRCRA during summer.

Close observations by ground search during the calving season each year has shown a decrease in the resident population. In 1981 the population was between 90 and 100 elk. In 1985, 2 technicians searched the area for 9 days during June and were able to see only 27 adults and 4 calves. Only 4 cows and 1 calf were seen on Atlantic Rim. No telemetered elk were using the area, so the observers were handicapped. State and local managers have also noted the reduction, and limited the hunting permits from 80 (in 1982) to 40 (in 1984 & 1985).

Feeding elk were found in sagebrush 26 percent, aspen 40 percent, mountain shrub 8 percent, and riparian or meadows 26 percent of the time. Resting elk used aspen 67 percent, riparian 18 percent, mountain shrub 9 percent, and sagebrush 6 percent of the time. Herds with both feeding and resting elk were seen in the same types previously mentioned 6 percent of the time.

Feeding elk located various distances from tree cover during the summer were as follows:

	#Locations/#Elk seen (cumulative)	
Distances	Feeding	Resting
≤25 yds	55/ 18	36/7
≤50 yds	64/103	36/7
≤100 yds	67/162	36/7
≤1/4 mi	70/171	36/7
≤1/2 mi	71/172	36/7
≤ 1 mi	71/172	13/7
> 1 mi	10/ 17	14/0

At least 87 percent of feeding elk were located either inside of or within 100 yards of aspen or willow cover. The few times they were seen over a mile from trees was usually very early in the morning in either the Atlantic Rim or Rendle Butte areas when they foraged in sagebrush or mountain shrub. Resting elk were in the trees or within 25 yards of timber about 90 percent of the time.

Resident elk shared habitat with domestic livestock, mule deer, pronghorn antelope, and wild horses. The times located and the number of elk seen in relation to other animals were as follows:

	Locations/#Elk Seen (cumulative)				
Distance	Mule deer	Antelope	Cattle	Sheep	Wild horses
≤50 yds	1/ 10	2/ 14	0/ 0	0/ 0	1/ 16
≤100 yds	2/ 25	2/ 14	0/ 0	0/ 0	1/ 16
≤200 yds	28/ 50	5/ 17	11/ 2	0/ 0	1/ 16
≤1/4 mi	66/178	22/ 80	47/ 63	5/ 12	4/ 16
≤1/2 mi	73/186	31/ 91	61/107	7/ 12	14/ 28
≤ 1 mi	78/191	44/125	80/182	12/ 21	19/ 35
> 1 mi	31/ 72	65/138	29/ 81	96/242	90/228

All 5 species occupied the area in the summer. Sheep were being herded so their movements were controlled and people were present. The majority of the elk stayed over a mile away from the sheep herds.

The pronghorns were not observed in timber stands. No antisocial response was noted when elk and antelope were observed within 50 yards of each other outside of timber stands.

Cattle, mule deer, and elk all used the same habitat on Miller Hill and in the draws on the west side of Muddy Creek and the north side of Rendle Butte. Close associations are probably conservative because of the poor visibility under the aspen. The animals appeared to be socially compatible. The few antagonistic encounters between elk and cattle showed that the elk were able to displace the cattle.

Wild horses were only seen in the McKinney and Muddy Creek areas and away from the aspen so encounters with elk were not common.

Elk locations in relation to human activity were as follows:

	#Locations/#Elk seen (cumulative)	
Distance	Traffic	Pedestrians
≤1/4 mi	11/ 36	1/ 25
≤1/2 mi	13/ 40	1/ 25
≤ 1 mi	18/ 41	2/ 28
> mi	91/222	107/235

Only 4-wheel drive roads pass within 0.25 mile of the prime elk use areas, and those roads on Miller Hill are controlled access. The elk on

Atlantic Rim receive the most disturbance, but some remain by using the aspen for hiding cover. The most used sites on Atlantic Rim were Beckman Canyon, Jep Canyon, and the draws south of Scotty's Canyon on the west side

Fall Elk Distribution

All migrant elk

Elk locations and sightings from September through November for the 1981 to 1984 period were used in the analysis for fall migrant elk use patterns. The travels of 49 telemetered elk are shown in Figure 30. One cow (31) made it through all 4 years, 3 cows (32, 15, and 22) survived for 3 years, 12 elk lasted for 2 years and 24 elk were monitored for only 1 year The number of sightings and elk seen for each year were as follows:

Fall	Times sighted	Elk seen	Number of telemetered elk
1981	45	322	5
1982	62	1,275	16
1983	32	1,036	23
1984	67	1,479	22
Totals	206	4,112	66

There was an average of 20 elk per sighting, with a range of 1 to 241. The largest group was photographed on November 1, 1982 in the refuge area protected by private access near Circle Mountain in Colorado.

A total of 929 locations of elk were recorded by telemetry fixes and sightings during the 4 fall periods. Most of the locations were made from an airplane. The elk breeding season, coupled with the hunting seasons, firewood gathering and the beginning of winter complicates the distribution and travel patterns of elk during the fall. They do, however, use the same routes each year to get to their winter range.

Figure 31 shows the percentages of feeding and resting migrant elk in relation to aspect during the fall. They show weak tendencies to use north facing slopes more than other aspects, but there was no significant difference between feeding and resting in relation to aspect or slope. Elk were found feeding or resting on less than 20 percent slopes 72 percent of the time. They used the steeper slopes in the canyons the rest of the time.

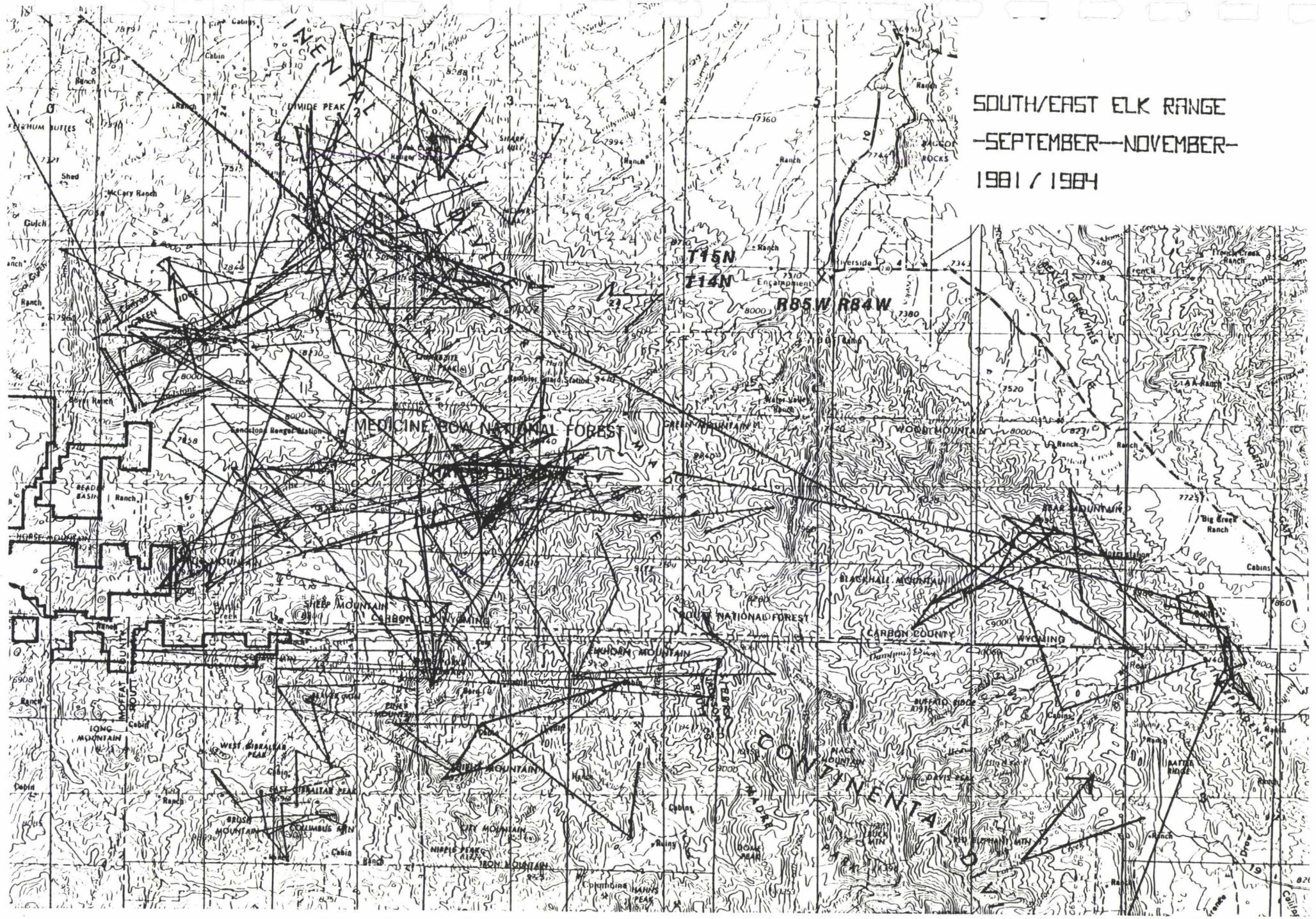

Figure 30. Fall movements of telemetered elk 1981-84.

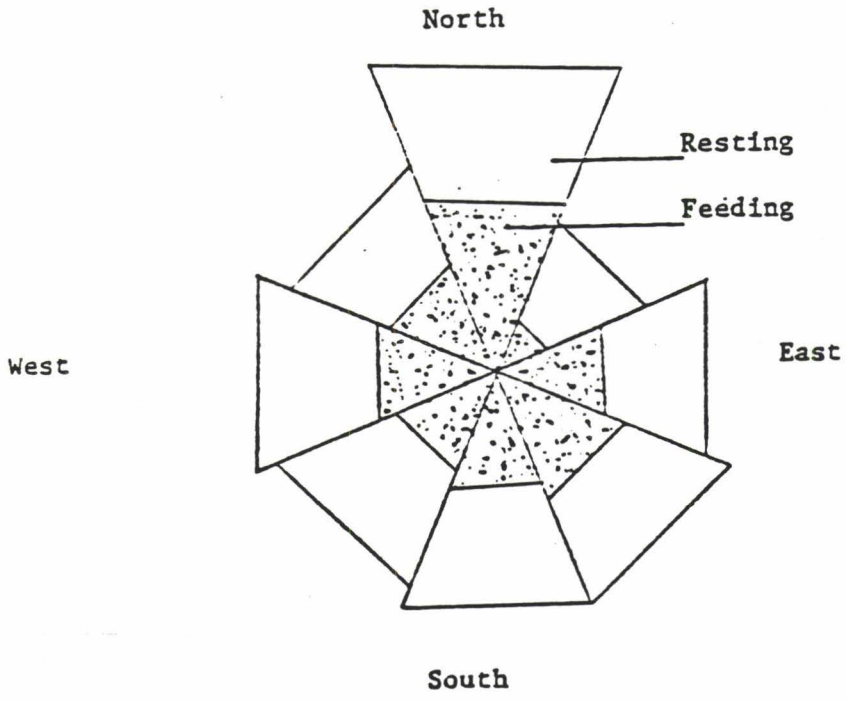

Figure 31. Percentages of elk use in relation to aspect for feeding and resting by all migrant elk on the KRCRA during fall.

Feeding and resting migrant elk during the fall were located various distances from cover as follows:

	#Locations/#Elk seen (cumulative)	
Distances	Feeding	Resting
≤25 yds	397/ 491	328/693
≤50 yds	434/ 908	338/794
≤100 yds	451/1,096	344/824
≤200 yds	462/1,252	347/847
≤1/4 mi	474/1,362	352/950
≤1/2 mi	479/1,483	354/950
≤ 1 mi	481/1,438	356/970
> 1 mi	0/ 0	0/ 0

During the rut and hunting seasons the elk stayed in hiding cover or thermal cover and only few rested or foraged over 100 yards from cover. Most of the elk found beyond 100 yards from cover were on their winter range after the hunting season in late November.

Habitat types use by migrant elk during the fall were as follows:

	Percent locations		
	Feeding	Resting	Feeding & Resting
Habitat types	(464 locations)	(355 locations)	(38 Locations)
Spruce-fir	23	12	3
Lodgepole pine-aspen	33	41	13
Aspen	16	20	8
Clearcuts	1	0	0
Mountain shrub	8	16	50
Riparian-meadows	5	2	3
Sagebrush	14	9	19

The use of the spruce-fir was influenced by snowfall. When the snow began in early October it was usually deep enough at the higher elevations to push the elk down. Elk using the higher elevations stayed in the forested areas and fed in the small wet openings.

As the elk moved down from the higher elevations they concentrated in the lodgepole pine-aspen habitat, where the majority of them stayed during the regular hunting season from October 15 to 31. In 1981 and 1982 the limited quota elk season extended to November 10, but in 1983 it only lasted to November 6 in most of the area west of the Continental Divide. By early November enough snow had accumulated to move the elk down into the aspen, mountain shrub, and sagebrush. Visibility increased as the season progressed. After the leaves dropped from the mountain shrubs, visibility was good enough to see elk feeding and resting, especially with a foot or more of snow on the ground. By late November some elk were on the sagebrush areas where they were easier to see.

Elk movements during the fall are difficult to predict, aside from the effect of snow accumulation which moves them down to the winter ranges. During the rut in September the bulls play an important role in deciding which elk goes where. With the peak of the firewood gathering activity and the hunting seasons that start in September and end in November, the human disturbance has an influence on the elk and is at the highest for the year.

During the fall the migrant elk used some of the same range as mule deer and cattle. The number of locations and elk seen in relation to other animals were as follows:

	#Locations/#Elk seen (cumulative)	
Distance	Mule deer	Cattle
≤25 yds	0/ 0	1/ 28
≤50 yds	2/ 22	2/ 32
≤100 yds	5/ 96	8/ 106
≤200 yds	47/ 397	28/ 219
≤1/4 mi	187/ 759	115/ 428
≤1/2 mi	197/ 761	161/ 468
≤ 1 mi	207/ 990	207/ 544
> 1 mi	720/3,122	722/3,568

Mule deer are common on the south end of the KRCRA where most of the close encounters occurred. The deer move to the lower country ahead of the

elk so they are less likely to be near elk in the fall. This data is very conservative because deer are difficult to see from an airplane.

Because the cattle are removed from the range in October, their contact with elk is limited. Cattle and elk dual-use of fall habitat is also restricted to certain areas such as Divide Peak, Green Ridge, Battle Creek and Shield, Circle, and Columbus Peaks in Colorado. The highest number of close sightings occurred in the refuge area of Colorado where the cattle and elk are concentrated in the wet meadows.

Elk locations in relation to human activities for all 49 telemetered migrant elk and their associates were as follows:

	#Locations/#Elk seen (cumulative)		
Distances	Traffic	Pedestrians	Timber harvest
≤50 yds	3/ 2	8/ 9	0/ 0
≤100 yds	3/ 2	8/ 28	0/ 0
≤200 yds	6/ 4	14/ 37	0/ 0
≤1/4 mi	37/ 71	43/ 74	5/ 0
≤1/2 mi	123/ 217	121/ 129	19/ 4
≤ 1 mi	211/ 275	241/ 233	33/ 30
> 1 mi	718/3,837	688/3,879	896/4,082

During the fall 77 percent of the migrant elk were located over a mile from traffic, 75 percent were over a mile from pedestrians, and 96 percent were over a mile from timber harvest operations.

Only 18 of the 49 telemetered elk were considered to be susceptible to road densities of over 0.5 mi/mi^2 because they stayed outside of wilderness and in areas with greater road densities. These 18 elk showed the following locations in relation to human activities:

Distances	#Locations/#Elk seen (cumulative) Traffic	Pedestrians	Timber harvest
≤50 yds	1/ 0	0/ 0	0/ 0
≤100 yds	1/ 0	3/ 4	0/ 0
≤200 yds	4/ 2	6/ 6	0/ 0
≤1/4 mi	20/ 30	18/ 6	4/ 0
≤1/2 mi	67/122	56/ 18	14/ 0
≤1 mi	113/122	104/ 30	14/ 0
>1 mi	138/411	147/503	227/533

These elk were located more than a mile from traffic 55 percent of the time, over a mile from pedestrians 59 percent of the time, and over a mile from timber harvest 90 percent of the time. The number of times the elk were located decreased as the distance to traffic or people decreased. The timber harvest operations were mainly those of firewood gatherers.

This data roughly agrees with Ward (1976) who found that traffic had little effect beyond 0.25 mile from roads in the Medicine Bow National Forest. In Idaho, Perry and Overly (1979) also found that roads reduced big game use of adjacent habitat, but to more than 0.5 mile away.

Elk Movements in Relation to Roads During the 1984 Hunting Season

Movements of 6 telemetered cows were monitored during the 1984 hunting season in the Jack Creek and Divide and Dexter Peak areas to determine the factors influencing elk movements. Elevations varied from 11,000 feet at Bridger Peak on the southern edge of the area to 8,000 feet on the northern edge. Over 90 percent of the area is forested with spruce-fir at the higher elevations and lodgepole pine and aspen at the lower. There are some riparian meadows in the bottom of the drainages and the south facing slopes are covered with sagebrush at the lower elevations. Seventy-three percent of the area is owned by the US Forest Service while the BLM and State own 7 percent and 6 percent, respectively. Private land comprises 14 percent of the study area, primarily along the western edge.

The major road into the area is the Jack Creek road, covering approximately 16.6 miles in the eastern half of the study area. Other developed roads which branch off include the Divide Peak Road (2.2 mi), Warren Road

(4.3 mi), North Spring Creek Road (4.1 mi) and the Nugget Creek Road (2.0 mi). The Deep Creek Road runs the entire length of the study area's western boundary. There are also 134.8 miles of undeveloped roads throughout the area. Lower road densities occur along the east Fork of the Savery Creek, and between Divide and Dexter Peaks. Because of the high road density, hunter access is good throughout much of the area. The private lands west of Divide and Dexter Peaks limit hunter access onto those lands and also reduce the impact on immediately adjacent forest lands.

From October 13 to November 3, 1984, 6 radio-collared elk were periodically located to determine their movements during the elk hunting season, which runs from October 15 to 31. Locations were made on the ground and from a 182 Cessna aircraft. Locations were made twice daily during the first 3 days of hunting season. On October 17, a storm left 6-14 inches of snow in the area, resulting in greatly decreased accessibility and difficulty in obtaining relocations. For this reason, the number of relocations for the first week of the season are greater than that for the second week.

Activity centers were determined with a grid system (Inglis et al. 1979) using square mile sections as grid markers. Each section was given a rating determined by the number of relocations falling within that square and the 8 adjoining squares. All contiguous squares with a rating of 2 or more were included within the activity center.

The miles of road in each section were measured using 1980 aerial photographs. Several logging roads have been developed since then and their locations were estimated by ground surveys. Improved roads were defined as any road maintained by periodic grading while unimproved roads were never maintained. There are no paved roads in the area.

Because hunting intensity was considerably greater the first week of the season, the analysis was later separated into the first part of the season (Oct. 15-19) and the last part (Oct. 22-30). In addition, inclement weather on the 17th resulted in snowdepths ranging from 6 to 16 inches. Discriminant analysis was run to determine the changes in road density and elevations in areas used by elk between the 2 time periods.

An activity center for each elk was also determined using the grid system. These individual activity centers were overlaid on topographic

maps to determine the areas which received heavier use. Each one-mile square section was given a rating determined by the number of activity centers using that section. Those sections with only 1 activity center received a rating of 1, those with 2 activity centers were rated 2 and so on. Analysis testing for trend in a contingency table was used to determine the variables affecting heavier use (Marascuilo and McSweeney 1977). The individual activity centers were further subdivided by the 2 weeks of the hunting season.

The activity center for the first week of the hunting season covered approximately 62 mi^2 (Figure 32). Nearly all forested habitat within the study area was included in the activity center, but by the second week the activity center shifted to the west and covered only 44 mi^2. This included a 7 mi^2 section along Green Ridge to the west of the Deep Creek Road. A comparison of two activity centers indicated a significant difference between elevations ($p < .0007$). The elk moved lower. Also, the miles of roads were significantly different with unimproved roads being more significant ($p = .0035$) than improved roads ($p = .0569$). A discriminant analysis was also run separating out the area of overlap. All factors appeared even more significant using this method. The elk moved into areas with more roads, but hunters were not using the roads because of snowdepths or access problems through private lands.

Individual activity centers for the entire season indicate an area of heavy use between Divide, Dexter, and Singer Peaks, covering 11 mi^2 (Figure 33). When compared with the surrounding areas, this area has a lower road density. A test for trend indicated a significant relationship between road density and degree of use ($X^2 = 6.92$).

Table 8 compares activity centers of the individual elk during each half of the hunting season. In spite of the small sample size, a significant difference between the 2 halves of the season was found comparing the size of the activity center, ($p = .8554$) miles of improved road ($p = .9660$) and miles of unimproved road ($p = .0075$). This indicates that during the second half of the season the elk moved into areas of slightly smaller size with slightly lower improved road density and substantially higher unimproved road densities. The validity of these indications, however, is questionable because of small sample size, complications due to snowdepth, and hunter access through private land.

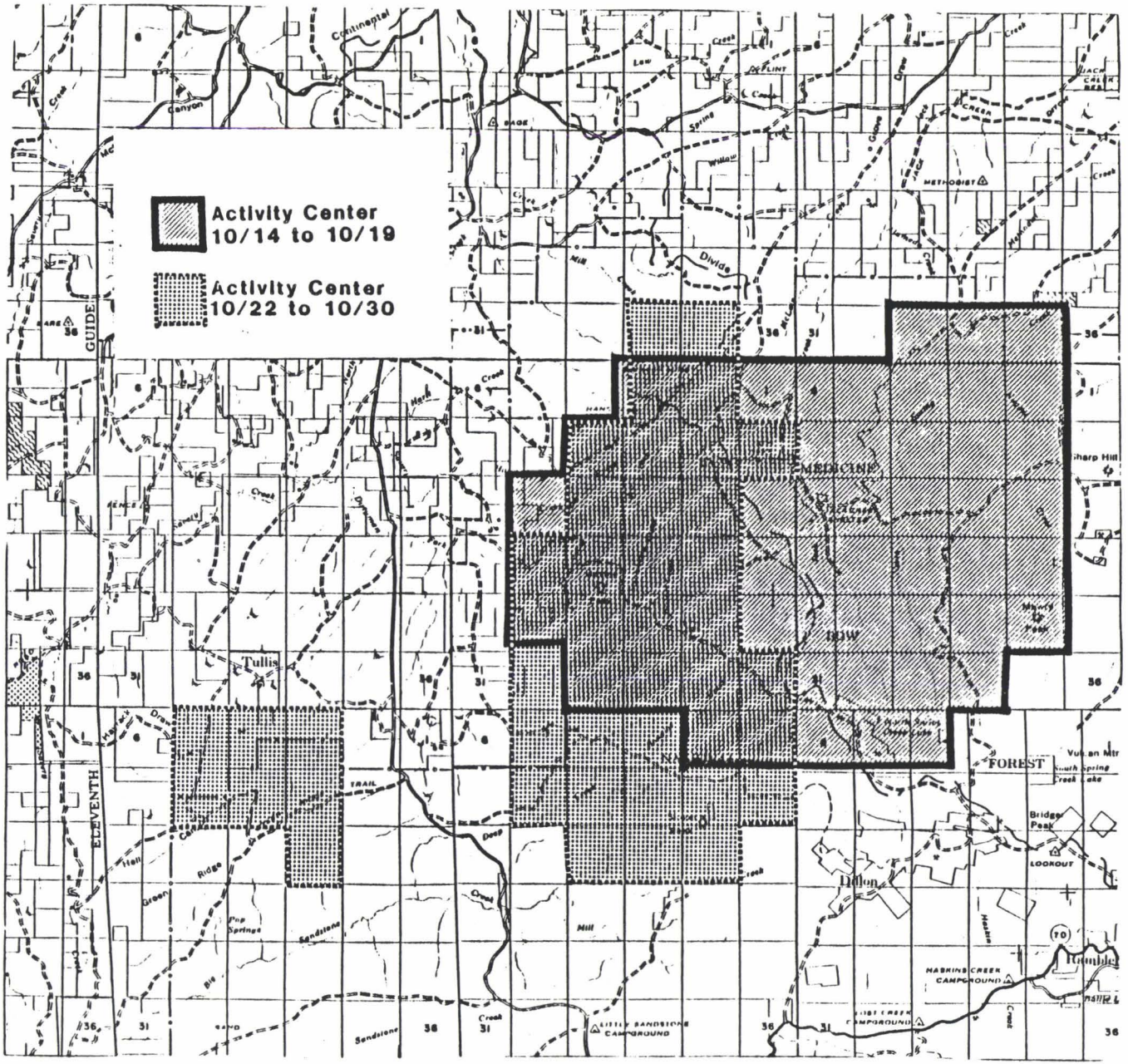

Figure 32. Activity centers during the two halves of the hunting season.

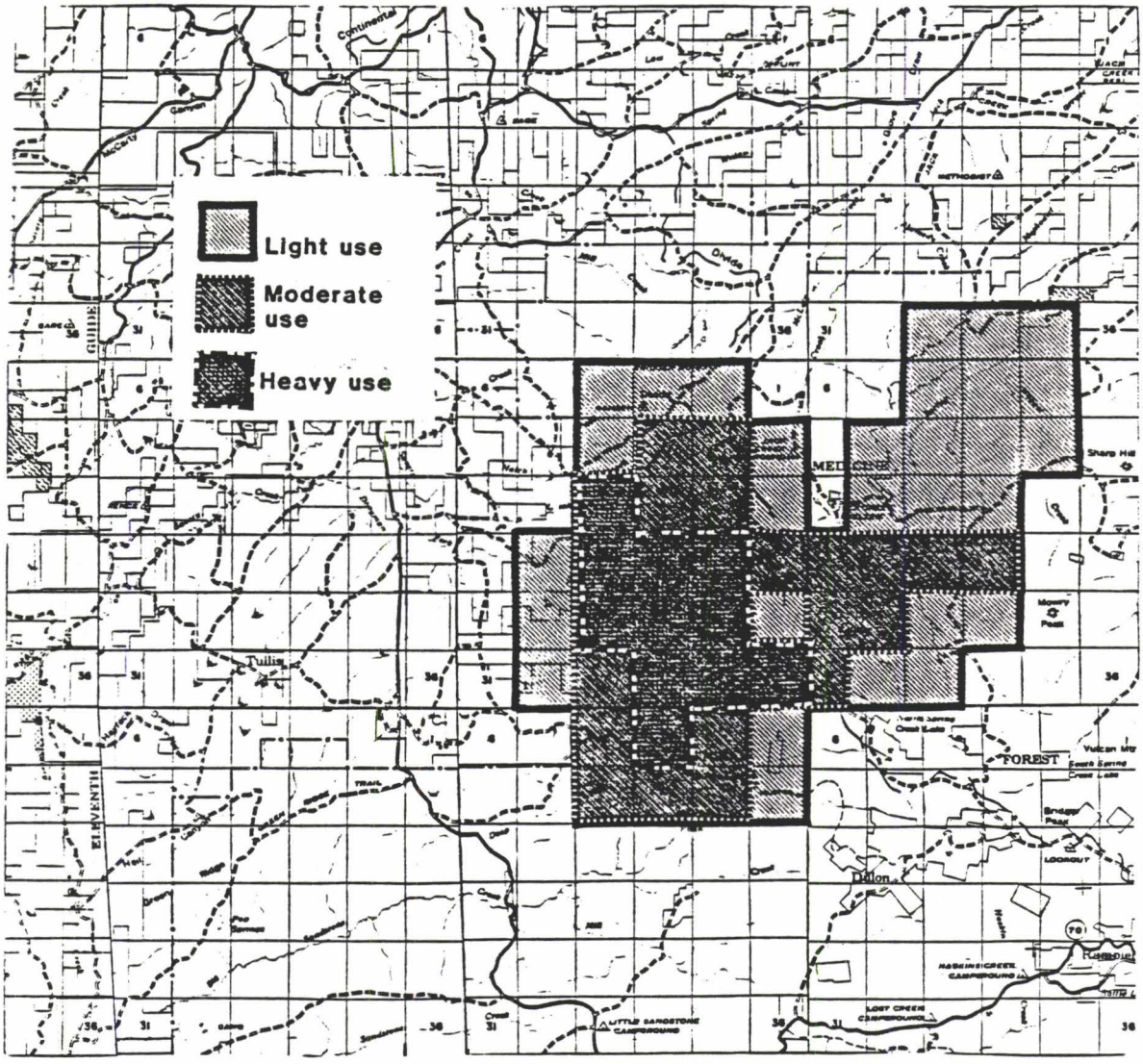

Figure 33. Individual activity centers indicating areas of light, moderate, and heavy use.

Table 8. Comparisons of activity centers for individual elk during the first and second halves of the season.

Elk no.	Week[1]	Size (mi^2)	Miles of road	
			improved	unimproved
31	1	14	0.71	0.21
	2	9	0	0.80
50	1	11	0	0.16
	2	3[2]	0.9	0.21
53	1	10	0.34	0
	2	12	0	0.82
56	1	4	0	0
	2	9	0	0.45
57	1	4	0	0
	2	8	0	1.13
58	1	11	0	0.61
	2	8	0.10	1.04
Average	1	9.0	0.175	0.163
	2	8.2	0.167	0.742

[1]Week 1 = October 14-19, Week 2 = October 22-30.

[2]Low figure due to high degree of movement within the period.

On an individual basis, most of the elk's movements could be explained by hunting pressure or weather factors. Taken as a group, however, very few generalities can be made. For this reason, descriptions of individual movements can be more revealing than a group analysis. Descriptions of each collared elk's fall movements follow:

Cow 56

Cow 56 is a resident elk on the Atlantic Rim winter range, but she had moved off the winter range during the hunting seasons of 1983 and 1984. She moved around to the east side of Miller Hill during the deer hunting season in 1983, and was found in the forested area of Divide Peak during late elk hunting season in early November. She returned to her traditional home range in early December. In 1984, she moved into the forest during deer hunting season, (Oct. 1-10) probably as a response to heavy hunting pressure and the little hiding cover available on the winter range on Atlantic Rim. She moved into the east Savery Drainage, southeast of Dexter Peak, and remained within a 10 mi^2 activity area until just prior to October 29. Apparently snowdepth made her return to her traditional home range. Unfortunately, on October 30 she was harvested north of Rendle Butte, approximately 10 miles from Dexter Peak.

Cow 58

Cow 58 was a summer resident on the winter range in the Rendle Butte area until the middle of September when the antelope hunting season opened and there was a large increase in human disturbance. She moved from the aspen cover patches on the north slopes of Rendle Butte to the coniferous forest around Divide Peak. During the first week of the elk hunting season in late October she was either between or east of Divide and Dexter Peaks where the total road density was low (0.61 mi). She moved south to Singer Peak during the second week to an area of higher total road density (1.14 mi), but with an improved road density of only 0.10 mile. Because of snowdepths most of the unimproved roads were impassable. The last two days of the elk season she was back on the south side of Divide Peak. The elevation in the Singer Peak area is about 200 feet higher than Divide Peak. In summary, during the elk hunting season this elk showed little movement related to hunters or weather influences.

Cow 31

This cow was trapped on Divide Peak on May 6, 1981. This was the fourth hunting season she survived. Every year during the early week of the hunting season she stayed in the Jack Creek Hill area where the improved road density was 0.92 mile. In 1984, her linear displacement from October 14 to 19 was only 1.5 miles, but the actual distance traveled was at least 13.5 miles. During this period, on several occasions, she was located within 100 yds of considerable traffic on an improved road. Her activity area covered 14 mi^2. By the second week cow 31 moved into the area around Dexter Peak with a total road density of 0.80 miles, but with no improved roads and snowdepths that also helped isolate the area from hunters. She has moved to this same area during the previous 3 hunting seasons. Cow 31 moved from an area with high hunter disturbance to an area of much less disturbance to survive the hunting season.

Cow 53

Cow 53 was in an area of relatively low road density (0.34 mi^2) during the start of the hunting season but moved to lower elevations the second week. She moved from the high ridge south of Jack Creek Lake into the east Savery Creek area where several collared elk had spent the first week (cow No's 50, 56, and 58), though the other collared elk had moved lower by this time. Road density in the new area was still fairly low (0.82), but the snowdepth was 5 to 10 inches less at this new area. She followed the same movements in 1983, moving lower when the snowdepth increased.

Cow 57

This cow spent the first week of the hunting season within a 4 mi^2 area with no improved roads, but within 1.13 mi^2 deinsity of unimproved roads. This small activity center indicates that she had located a safe "refuge" area and stayed there. Once again, snowdepth limited the use of unimproved roads. This shift may have resulted from snowdepths since elevations were slightly lower in the new area.

Cow 50

Cow 50 started the elk hunting season on the south side of the east fork of Savery Creek at a high elevation, which provided a fairly good "refuge" area with a road density of only 0.16 mi^2. When the snow came on October 16, she moved to a substantially lower elevation along Green Ridge where the road density was considerably higher. She covered a very large distance the second week but with an activity center of 3 mi^2. Her movements appeared to be weather related because she moved into an area of decreased snowdepth rather than less roads. The snow still made the roads on Green Ridge more difficult to travel and there are several road closures in the area that gave her some protection. This cow stayed in the higher habitat around Singer and Dexter Peaks to survive the 1983 hunting season.

Summary

The six radio-collared elk monitored during this study showed a preference for timbered areas with lower road density or impassable roads due to snowdepths. The road density does not appear to be as critical a factor as the weather and consequent snowdepths, however. During the second half of the season many of the elk moved to lower elevations and less snow. This movement made them more vulnerable to hunters. Individual elk movements were difficult to predict. The combination of varied hunting pressure and the build-up of 6 to 16 inches of snow complicated elk habitat use. They moved downhill to get out of the deep snow and tried to stay away from hunters by finding areas where access was reduced either by snowdepths or restricted by private property.

North end resident elk

Elk locations and sightings from September through November for the 1981 to 1984 period for the 7 telemetered elk and their associates that were residents of the north end of the KRCRA are shown in Figures 34. Elk were located 130 times and 308 elk were seen in 18 groups with an average of 17 elk per group. Two cows (12 and 15) made it through 2 hunting seasons and were killed but not harvested the third year. Cow 15 traveled southwest to Green Ridge during the 1983 hunting season to escape. Cow 12

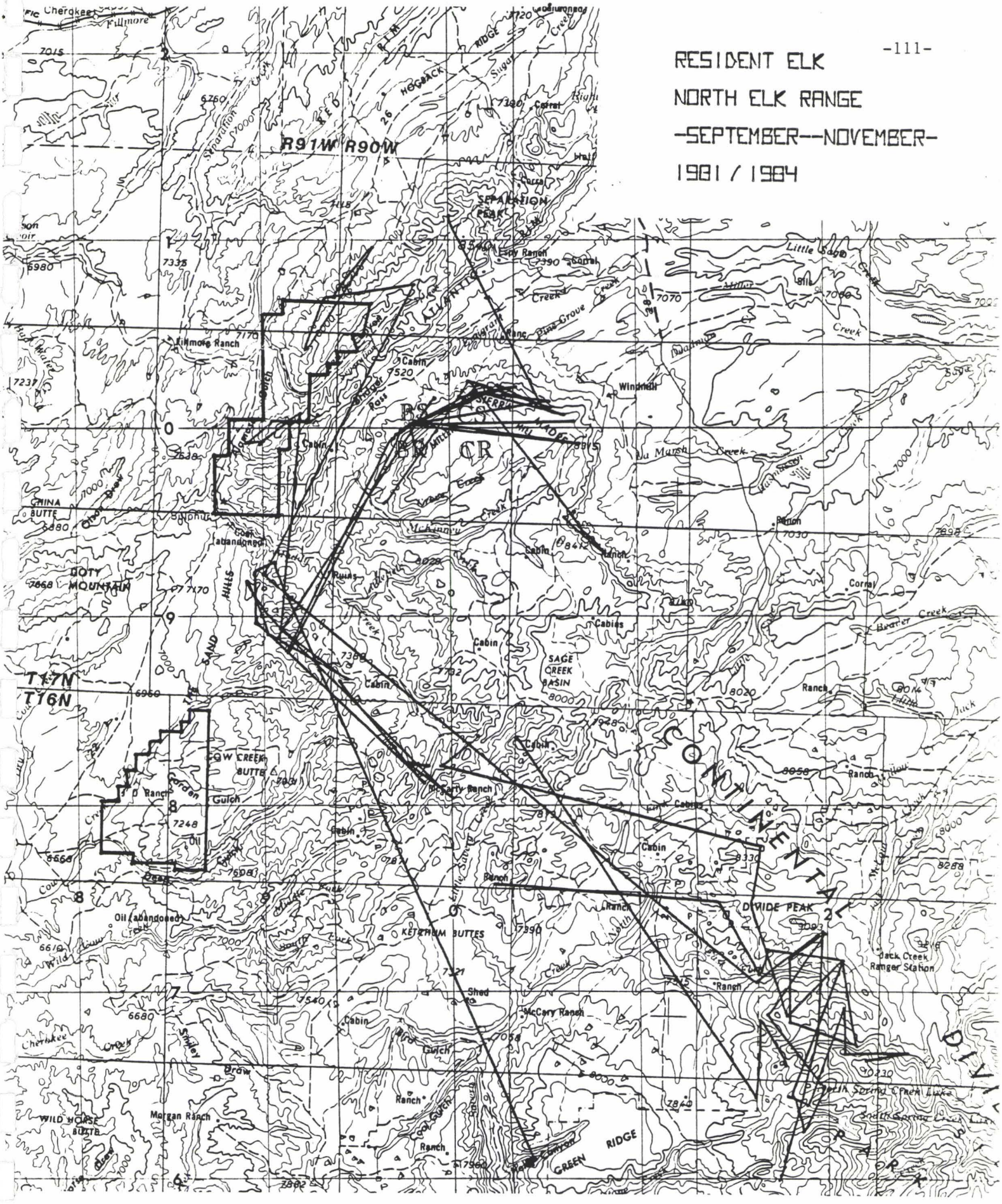

Figure 34. Fall movement of resident telemetered elk on the north end of the KRCRA, 1981-85.

stayed on the north side of Miller Hill in 1981 and 1982, but moved to Atlantic Rim and was killed in Snowshoe Canyon in 1983.

Cow 56 survived the 1983 season on the north side of Miller Hill. She moved to the Dexter Peak area by the opening of the 1984 season, and was harvested North of McCarty Canyon on October 31. Three other elk were killed the first year (3, 19, and 29) but cow 19 was not harvested. Cow 58 managed to survive the 1984 season by moving to Divide and Dexter Peak during the 1984 season. Even with the limited quota, either sex permits, and limited access in the Miller Hiller and Muddy Creek areas, the resident elk receive heavy hunting pressure. They are particularly vulnerable in the small aspen patches after the leaves have fallen and snow is on the ground.

Figure 35 shows the percentages of feeding and resting resident elk in relation to aspect during the fall. They used west to north facing slopes where aspen was available, and there was no significant difference between feeding and resting in relation to aspect or slope. They were found feeding or resting on slopes less than 20 percent 60 percent of the time and used the steeper slopes near the top on the ridges the rest of the time.

Habitat types use by resident elk during the fall were as follows:

	Percent of Locations		
	Feeding	Resting	Feeding and resting
Habitat type	(52 locations)	(59 locations)	(5 locations)
Aspen	29	42	
Riparian-aspen	17	14	40
Sagebrush	25	14	20
Mountain shrub	8	17	40
Lodgepole-aspen*	21	14	0

*Used by telemetered cows 15, 56, and 58 when they moved to the National Forest during hunting seasons.

Elk used the aspen and mountain shrub types for hiding and thermal cover. Over 70 percent of the feeding and resting also occurred there. Elk used sagebrush in close proximity to cover. Over 95 percent of the feeding and resting elk were found either in or within 100 yards of cover.

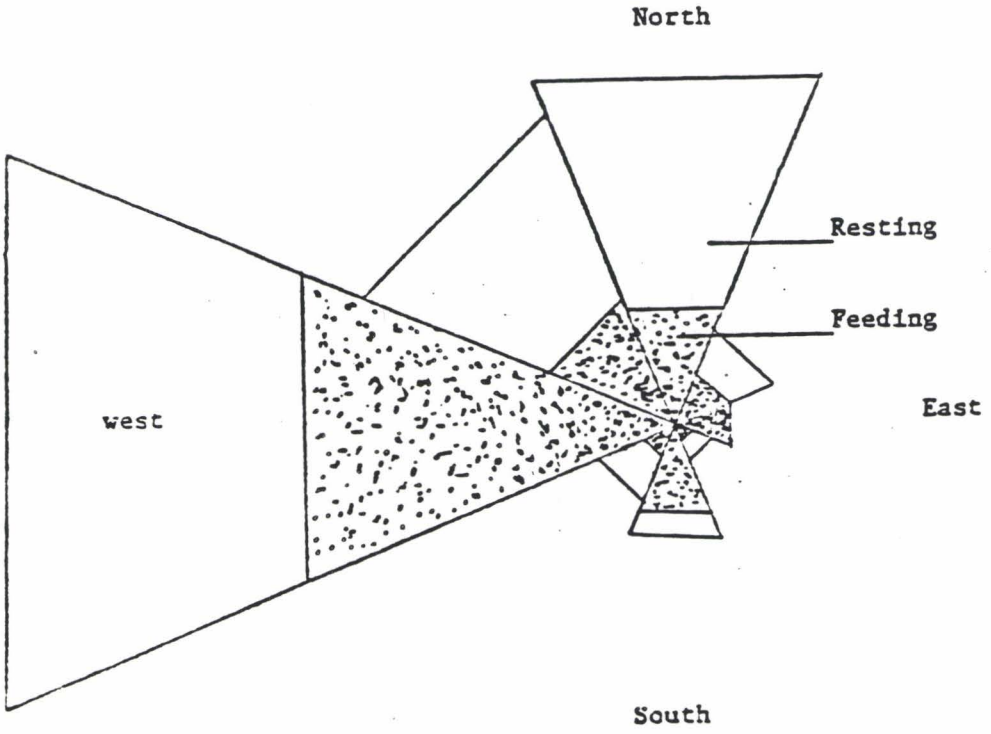

Figure 35. Percentages of elk use in relation to aspect for feeding and resting elk on the north end of the KRCRA during fall.

Three cows moved to the coniferous forest during the hunting season and accounted for some use of lodgepole pine-aspen habitat. By late November some elk were using sagebrush on the winter range in the area.

Movements of the resident elk are associated with the hunting seasons that start with pronghorn antelope and grouse in September and close with the elk season in late October or November. The small patches and strips of aspen are easy to hunt and the elk have difficulty hiding. Their movements during the mule deer and elk hunting season reflect the heavy human disturbance. No good record was possible of elk distances from pedestrians because of the difficulty of seeing people in the trees and the large percentage of people hunting from vehicles. Elk locations in relation to traffic were as follows:

	#Locations/#Elk seen (cumulative)
Distance	Traffic
≤50 yds	1/ 0
≤100 yds	1/ 0
≤200 yds	2/ 0
≤ 1/4 mi	15/ 34
≤ 1/2 mi	30/ 75
≤ 1 mi	46/110
> 1 mi	84/298

All the traffic in this area is related either to recreation (specifically hunting) or livestock management. Hunters are able to hunt from vehicles, and they use roads of various types from 4-wheel drive to county graveled roads.

During the fall the resident elk were located the following distances from other animals:

Distance	#Locations/#Elk seen (cumulative) Mule deer	Antelope	Cattle	Sheep	Horses
≤50 yds	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0
≤100 yds	5/ 0	0/ 0	0/ 2	0/ 0	0/ 0
≤200 yds	21/ 0	0/ 0	13/ 0	0/ 0	0/ 0
≤1/4 mi	65/137	8/ 0	26/ 42	0/ 0	0/ 0
≤1/2 mi	69/140	13/ 4	27/ 47	5/ 30	3/ 0
≤1 mi	78/151	28/ 48	48/162	9/ 35	7/ 10
>1 mi	52/157	102/260	82/146	121/273	123/298

The locations in relation to deer and cattle are conservative because of the difficulty of seeing animals in the aspen. Antelope and horses stay away from tree cover so close encounters with elk were minimal. The domestic sheep are herded, which means people are usually near the sheep.

Individual Cow Elk Monitoring

Six different cows wearing activity tip-switch collars were monitored continously for 2 to 3 day periods to determine their travels, activities and habitat use. Comparisons between elk were impossible because of the changes in time of year and habitat availability. The results from each cow are presented on a case history basis for each area.

Atlantic Rim-Miller Hill

Cow 12

This cow was a resident of the Atlantic Rim and Miller Hill area on the north end of the KRCRA. She was monitored for 3 different periods. The first 2 were from July 20 to 23 and from August 3 to 6, 1981 while she and her associates used the north side of Miller Hill. The habitat there is mainly aspen and riparian willow with sagebrush on narrow ridges. There are several beaver dams throughout the area, although the streams are small. Cow 12 used an area about 0.5 mile wide on the west, 1 mile wide on the northeast, and approximately 7 miles long. The elevation varies from 8,390 feet on top of Miller Hill to 7,600 feet at the Lambert Ranch on the northeast. The weather was partly cloudy to clear, with calm winds and

temperatures from 50° F to 55° F at night and 85° F to 90° F during the day. A full moon illuminated the study period nights in July, but a new moon in August kept those study nights dark. Maps and activity charts are shown in Figures 36, 37, 38, 39.

On July 20, beginning at 1500, cow 12 and her 9 associates (4 cows, 5 calves) spent the first 19 hours in aspen-sagebrush covered ridges on the northwest side of Miller Hill. She fed and rested during the first night and early the next morning, but at 1000 on July 21 an unknown cause displaced the elk 1.75 miles to the west. The elk moved for 45 minutes and crossed an open slope. Late that afternoon they began moving back toward the original location.

At 0400 on July 22, while relocating the monitoring recorder on Miller Hill, the observer spooked cow 12. She then moved about 3 miles to the north end of Miller Hill. For the next 1.5 days she stayed in this area, feeding in aspen with her calf and another cow. Cattle were seen feeding and resting in the open areas within 100 yards of the elk.

The tip switch did not work when the elk was seen feeding on aspen twigs and leaves with her head up. However, the signal strength showed enough change to indicate activity.

Cow 12 was active 58 percent of these 1.5 days and stayed in the aspen and riparian habitat most of the time. Thermal and hiding cover could not be differentiated.

The second monitoring period started at 1330 on August 3 when the 3 elk were on the northeast face of Miller Hill. There were another 14 elk (9 cows, 4 calves, and a spike) seen at 0620 on August 4 feeding on a sagebrush covered ridge. A third group of 21 elk (13 cows, 6 calves, 1 spike, and a 5-point bull) were seen about 0.7 mile to the northwest.

While moving the recorder, the observer spooked 12's group and within an hour they moved 3 miles to the northwest. Cow 12 used the aspen riparian meadows below Miller Lake and spent 53 hours in this 94-acre area. Cattle were seen feeding within 200 yards of the elk. Cow 12 was active about 59 percent of this period of time and fed both day and night. Thermal and hiding cover could not be differentiated here, either.

Cow 12 was not monitored again until June 13 to 16, 1983 when she was found using a small west-facing aspen draw on the east ridge of Separation Creek on Atlantic Rim. She came to this area from the north side of Miller

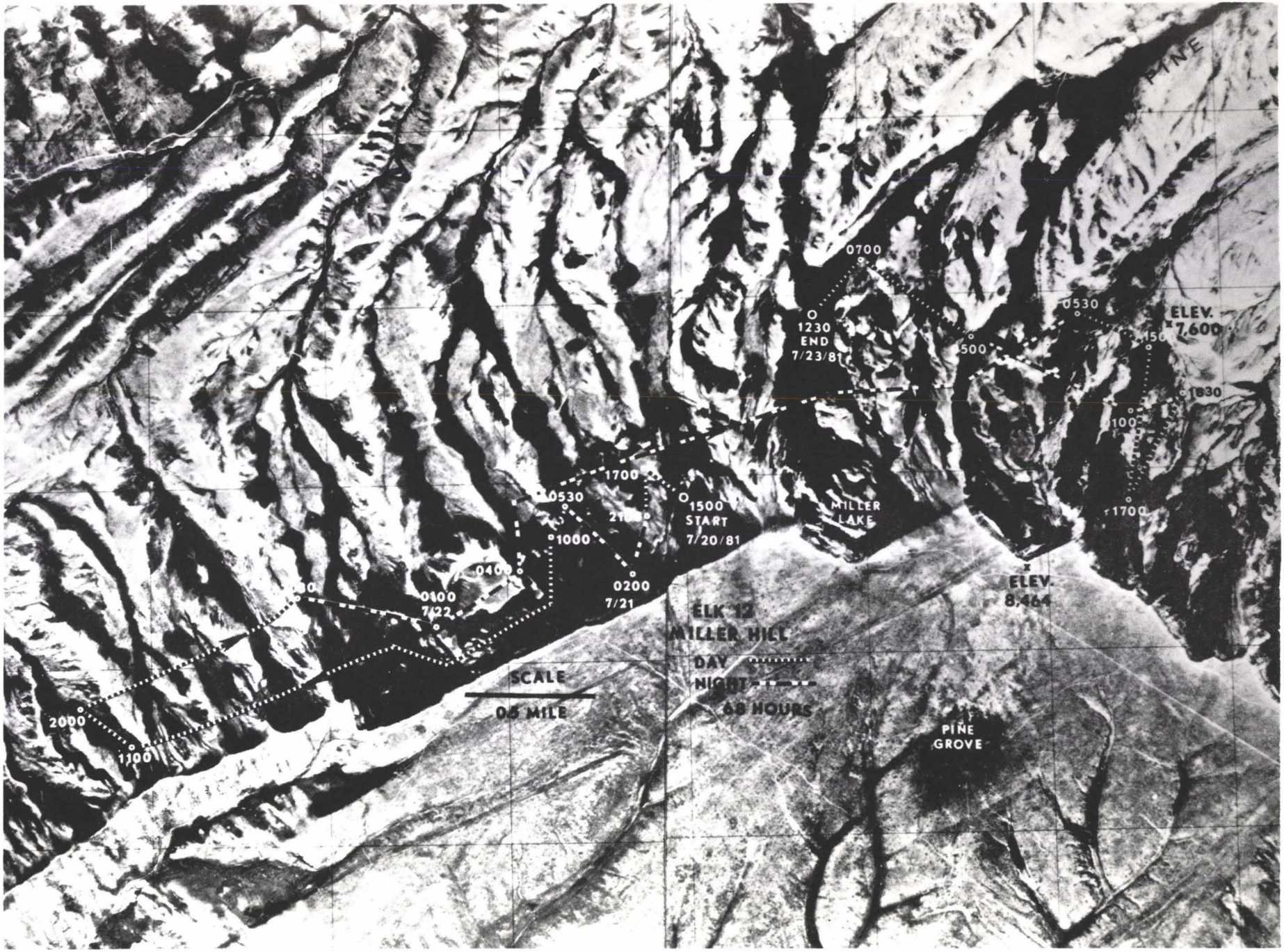

Figure 36. Cow 12 travels during monitoring July 20 to 23, 1981 on the north side of Miller Hill.

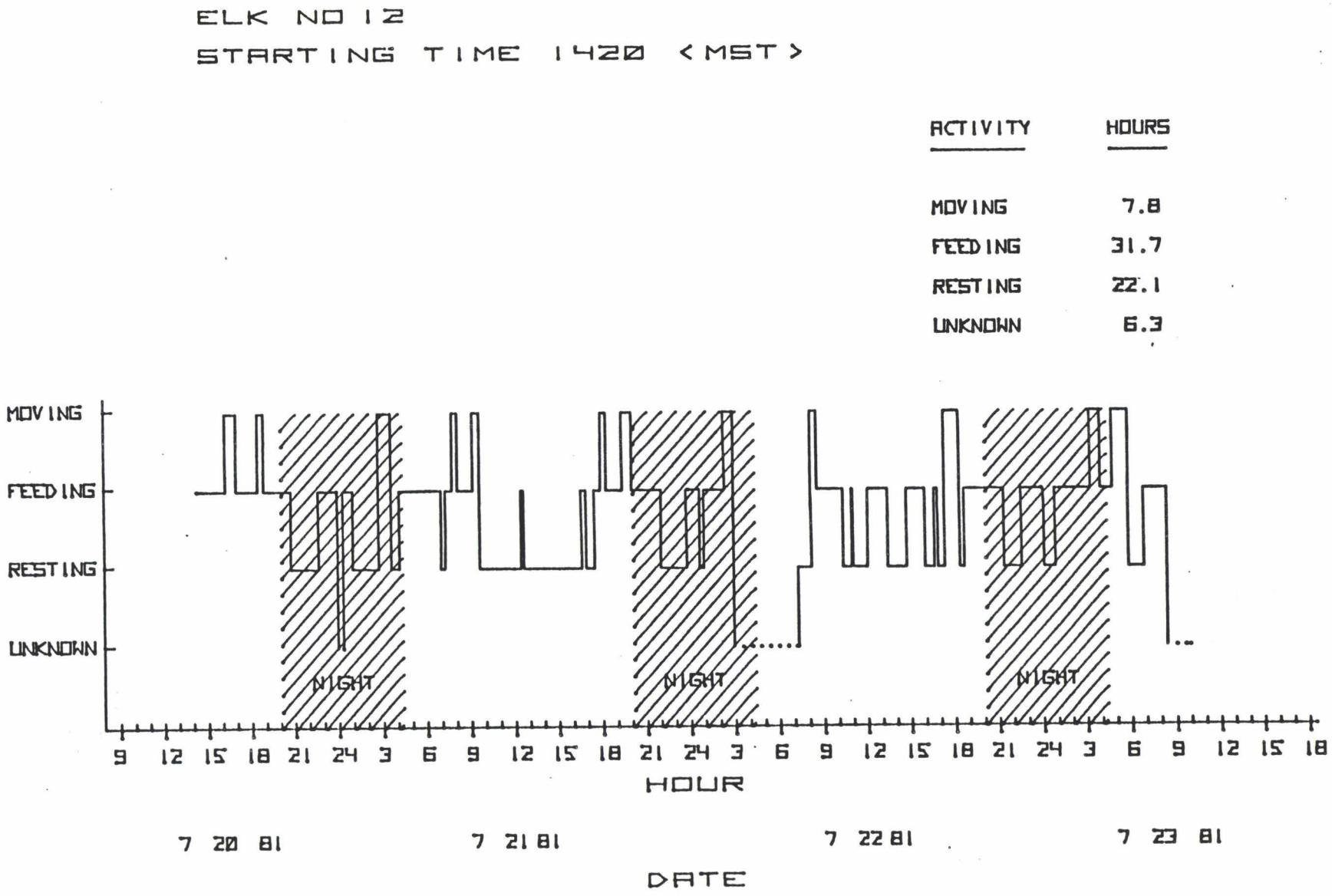

Figure 37. Cow 12 activity recorded during July 20 to 23, 1981.

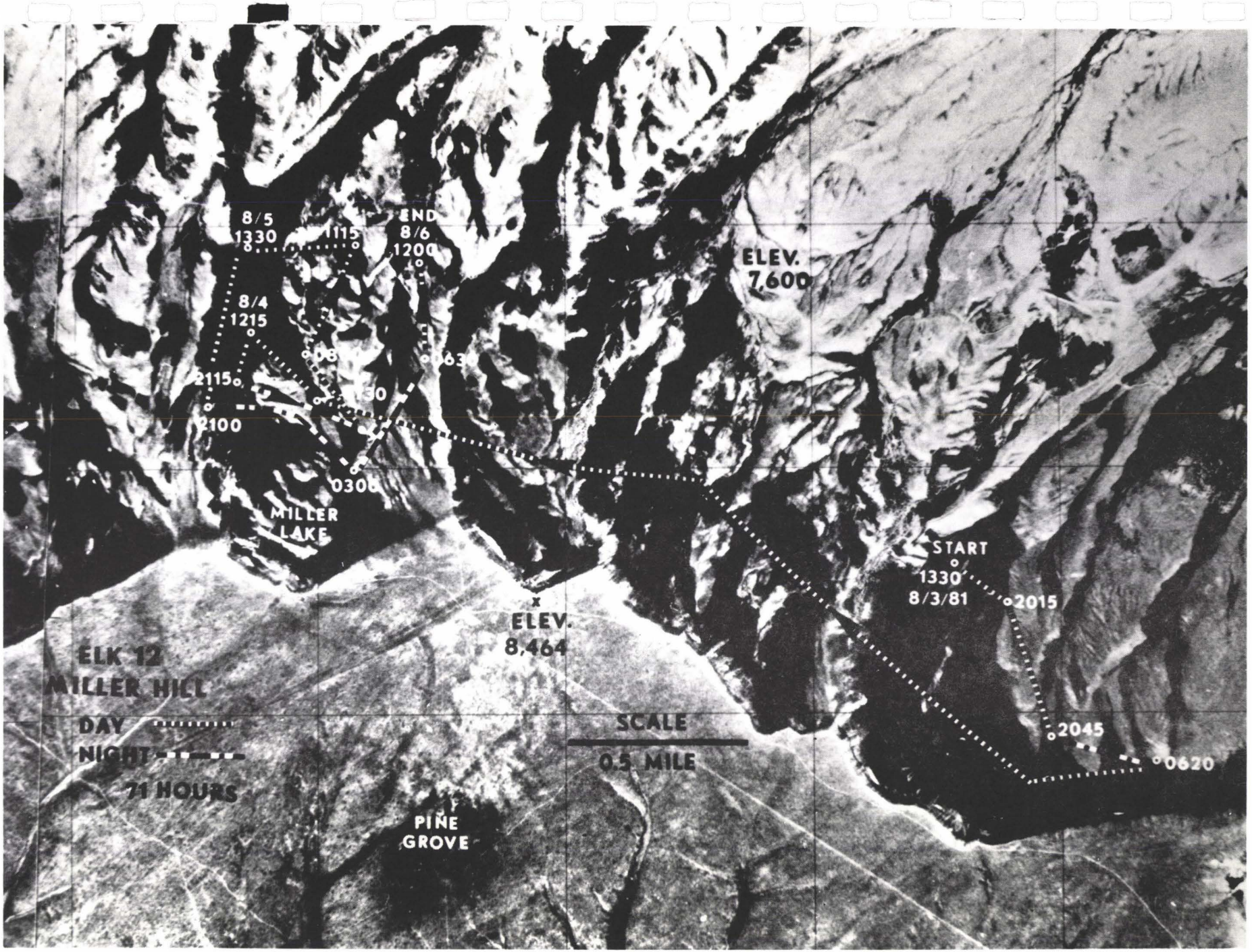

Figure 38. Cow 12 travels during monitoring August 3 to 6, 1981 on the north side of Miller Hill.

ELK NO 12
STARTING TIME 1230 <MST>

ACTIVITY	HOURS
MOVING	6.8
FEEDING	34.7
RESTING	27.6
UNKNOWN	1.5

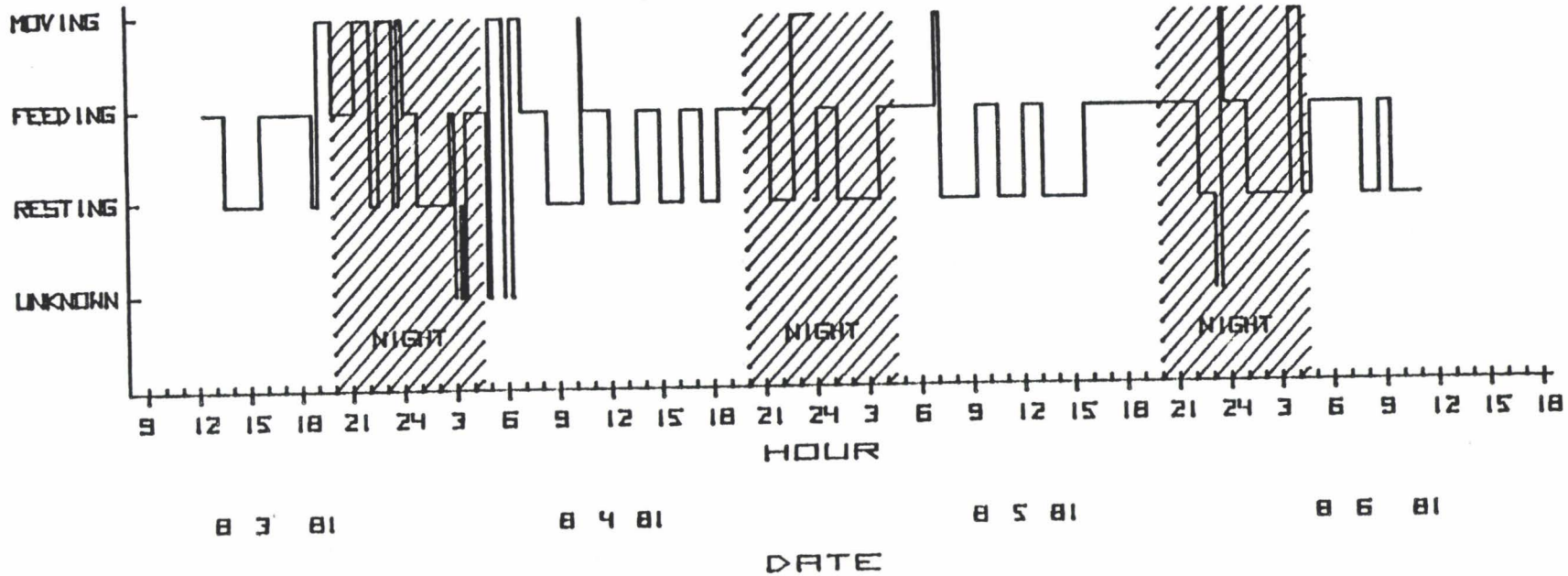

Figure 39. Cow 12 activity recorded during Agust 3 to 6, 1981.

Hill between June 1 and 8. The recorder and observation site was on top of the west ridge of Separation Creek about 0.75 mile directly across from the aspen draw. Elevations varied from 7,600 to 8,100 feet. Her travels and activity are shown in figures 40 and 41.

The weather was quite favorable with afternoon temperatures of 72° F, however there was frost on the morning of June 14. Winds ranged from 0 to 15 MPH with light rain showers of short duration on 2 of the afternoons. A quarter moon was visible during the evenings.

During the monitoring period this cow used 37 acres which were subdivided as follows: 13.3 ac. aspen; 10.4 ac. sagebrush; 6.6 ac. meadow; and 6.5 ac. shrub. Separation Creek runs through the meadow at the lower end and there are two beaver ponds within the aspen. The canopy cover, sight distance and basal area measured where the cow rested and ruminated (thermal) and moved when harassed by humans (hiding) were as follows:

	Tree DBH	Basal Area	Stems/	Percent visibility 1 x 8' board			Percent
Cover	(In.)	(Sq ft/ac)	Acre	33 ft	66 ft	98 ft	canopy
Thermal	3.0	178	900	78	45	36	61
Hiding	1.9	96	11700	51	11	0	60

The main differences in the 2 areas were the basal area of trees and number of stems per acre. The horizontal visibility was reduced in the hiding area but the percent canopy cover stayed about the same.

Cow 12 was first seen feeding alone in sagebrush at 0712 on June 14. That afternoon her calf was seen bedded in sparse aspen within 30 feet of 5 feeding mule deer. The cow got the calf up and began grooming it; a few mintes later the calf touched muzzles with a doe deer. Cow 12 then exhibited aggressive behavior and ran all the deer off about 20 yards where they resumed feeding.

Early on the morning of June 15, 5 other elk entered the same aspen draw but did not immediately join cow 12. At 0730, cow 12's calf got up from some serviceberry bushes and nursed. From 0900 to 1000, a pickup truck came up Separation Creek and stopped about 300 yards from cow 12 feeding in an opening in the aspen. She ran 200 yards up the draw into the

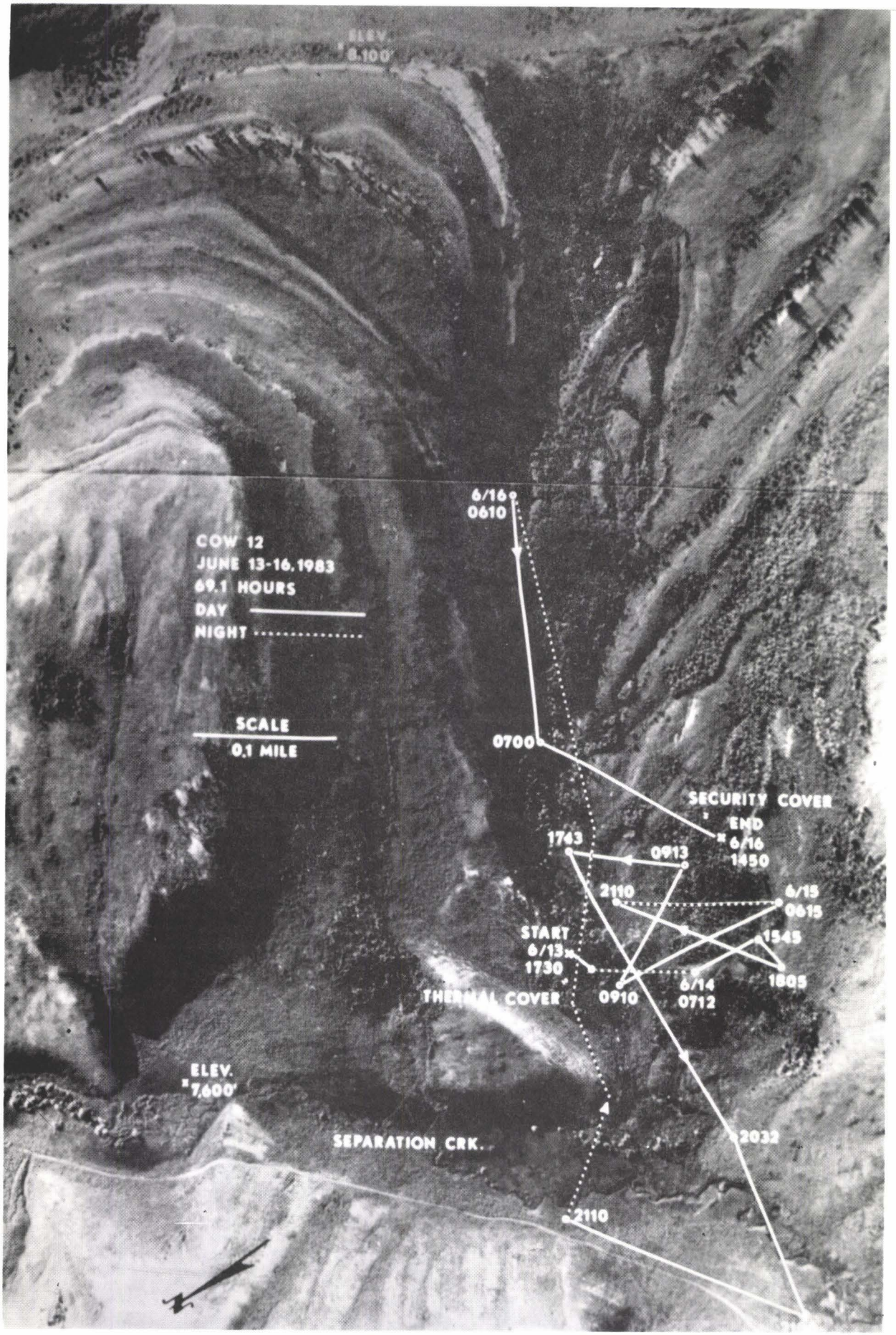

Figure 40. Cow 12 movements on Atlantic Rim during June 13 to 16, 1983.

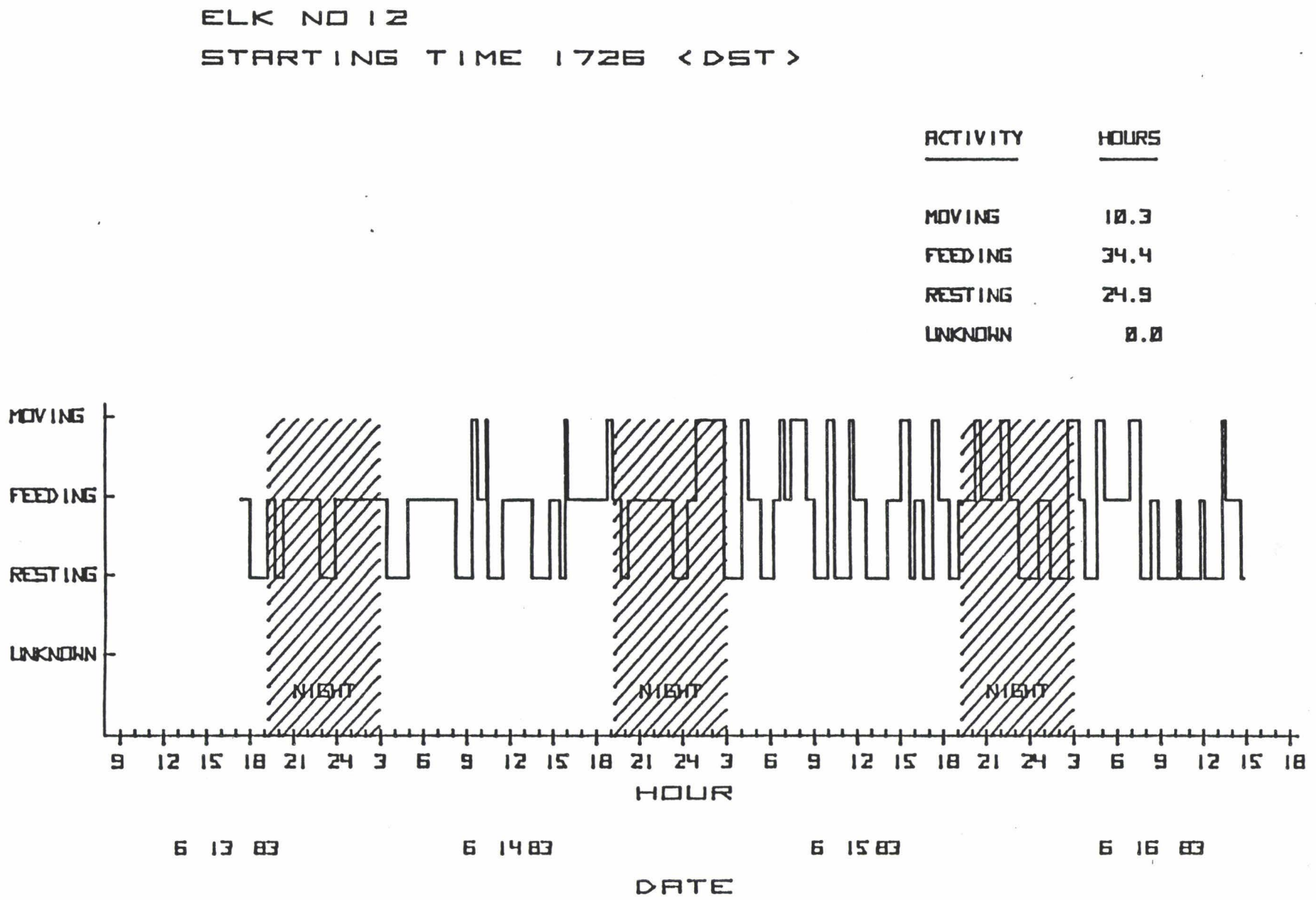

Figure 41. Cow 12 activity recorded during June 13 to 16, 1983 on Atlantic Rim.

aspen which was considered the hiding cover site. She began feeding about 5 minutes after the pickup left and then lay down to rest.

Later that afternoon 3 cows entered the draw near cow 12; within 30 minutes she chased these cows. At 1950 she was seen with 6 other elk feeding near a beaver pond, where she antagonized one yearling until it swam across the pond to escape. Her calf nursed at 2019 and disappeared into the aspen while she joined the other elk feeding in the meadow along Separation Creek. On July 16 at 0610 she nursed her calf near the top of the draw and was accompanied by 5 cows and another calf. She charged a couple of these cows, but did not make physical contact.

Cow 12 and her calf returned to Miller Hill between June 20 and 28. Her calving site in 1983 on Atlantic Rim was approximately 2.5 miles line-of-sight from the site on the northwest side of Miller Hill which was used the 2 previous years.

During the monitoring period cow 12 was either feeding or moving 64 percent of the 69.6 hours. She was active both day and night and her resting and ruminating periods were relatively short. The first night her activity pattern showed more feeding than resting and not much travel. It is possible that the calf was born sometime during the first 12 hours, but she could not be seen. Her frequent changing of activity after the first day shows both her concern for the safety of the newborn calf and her need for food and rest. This pattern is quite characteristic of other elk observed after their calves were born, as studied, for example, on the Bighorn National Forest and the Medicine Bow Range (Ward 1973, Ward et al. 1980). For the first 3 or 4 days the cows are very attentive to the calf. After the calf has a chance to get strong enough to move, the pair usually join with other cow and calf groups and travel more extensively.

Cow 56

Cow 56, her calf, and her 12 associates (5 cows, 5 calves and 2 bulls) used 3 aspen draws just south of Scotty's Canyon on the northwest side of Atlantic Rim during the 69.8 hour monitoring period of July 24 to 27, 1984. Her travels and activity are shown in figures 42 and 43. The elevation ranged from 7,400 to to 7,950 feet. The habitat is sloping sage-grassland hillsides with bottoms of sparse to dense aspen with some mountain shrub in smaller draws and on the fringe of some aspen stands. A

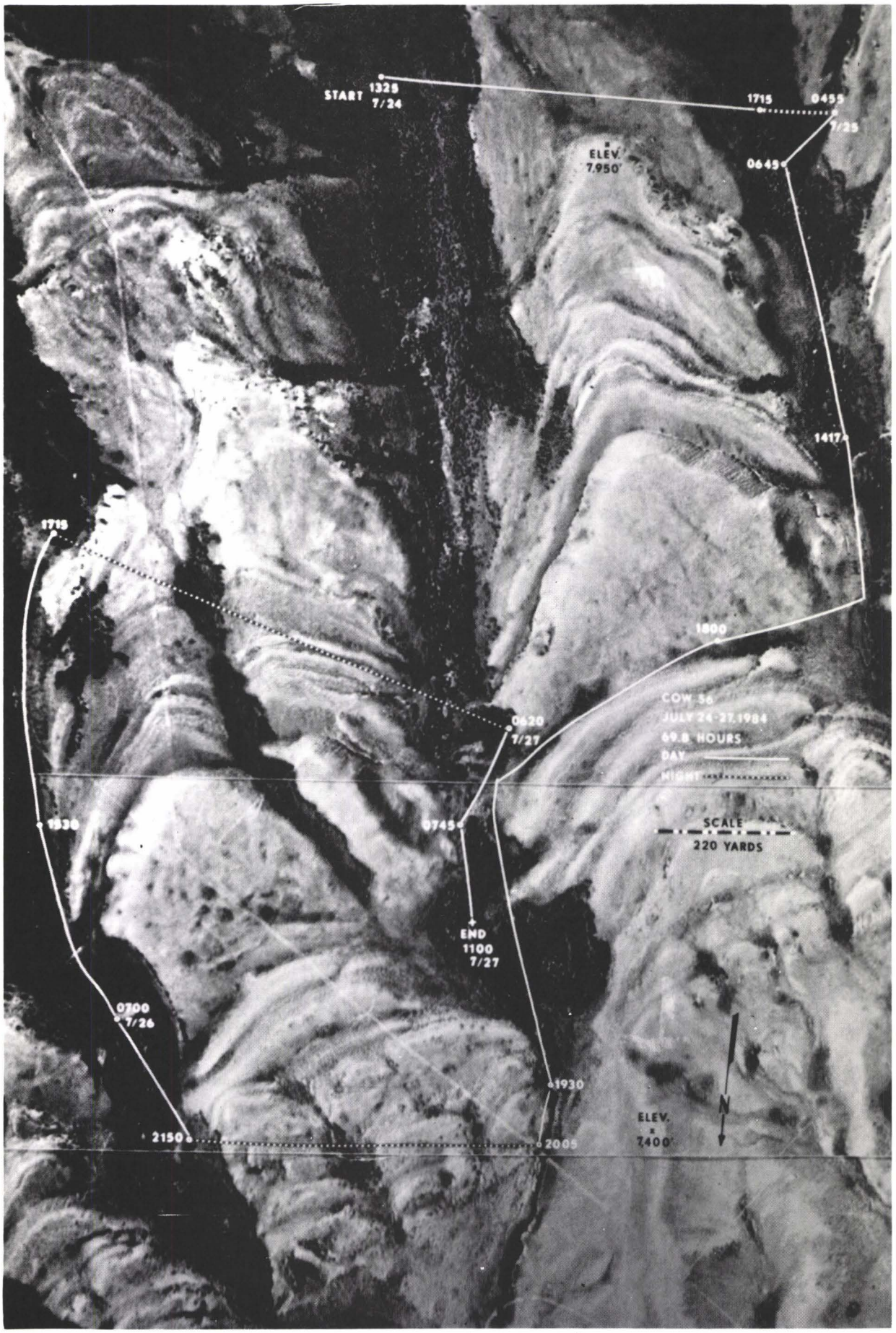

Figure 42. Cow 56 movements on Atlantic Rim during July 24 to 27, 1984.

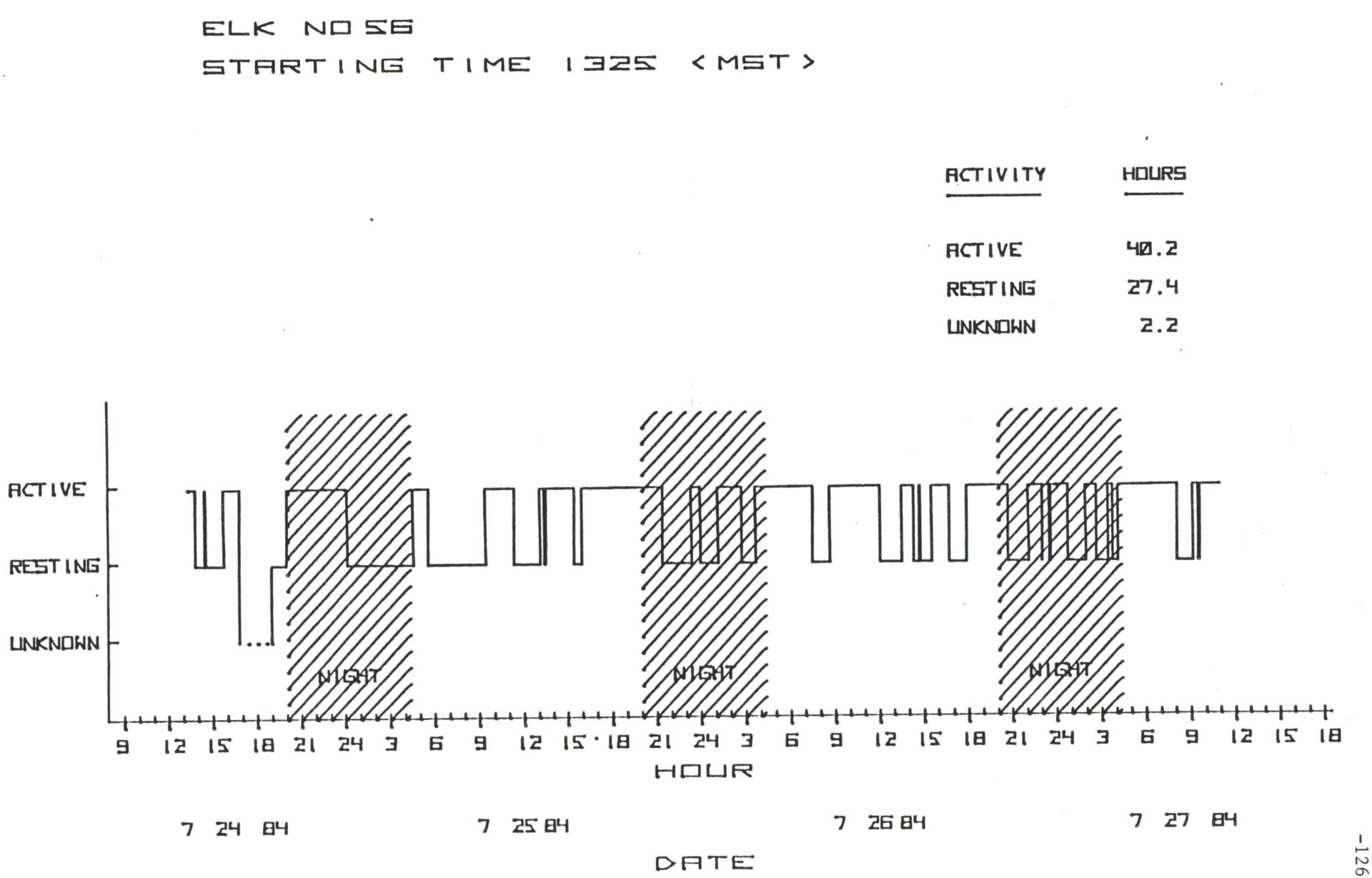

Figure 43. Cow 56 activity recorded during July 24 to 27, 1984 on Atlantic Rim.

few limber pine trees are on the drier open slopes. The weather was favorable with afternoon highs in the mid 80's° F and nights in the mid 50's° F. The quarter-moon rose at 0200.

Cow 56 was active 58 percent of the time both day and night. She used 242 acres which contained 31 ac aspen (13%), 33 ac mountain shrub (14%), 158 ac sagebrush-grassland (65%), and 20 ac edge of aspen and sagebrush (8%). She showed a strong preference for aspen during the day.

Cow 56 and cow 12 demonstrate the use of habitat on Atlantic Rim during the spring and summer. They both show a strong preference to use small aspen patches for daytime thermal and hiding cover. The stands are long, narrow, and small. These areas are evidently essential to elk welfare on Atlantic Rim and should be preserved or restored if coal mining takes place.

During the hunting seasons the elk are easily moved out of these aspen areas and have a difficult time evading hunters. They resort to distance movements and also seek more remote hiding cover. Three survivors (15, 56, and 58) have even moved to the coniferous forest to get away from hunters. However, 2 of these cows (15 and 56) made the mistake of either staying in or returning to the Rendle Butte and McCarty Canyon area where they were killed.

Forested Areas

Cow 7

Cow 7 and her associates spent the summer in an area of mainly lodgepole pine-aspen, but with strips of aspen and sagebrush and some pockets of spruce-fir, in the Jack Creek area east of Divide Peak on the north end of the National Forest. Her activities and movements were monitored from August 17 to 30, 1982 (70.3 hours).

The travels and activities for Cow 7 from August 17 to 19, 1981 are shown in Figures 44 and 45. She was active 59 percent of the time and fed and rested both night and day. She stayed in the North Fork of Spring Creek in a mixture of vegetative types, including clearcuts, and with 0.92 mi/mi^2 of improved roads and a considerable amount of human activity. The weather was clear with temperatures in the 40's at night and 70's during the day. A full moon came out at 2200.

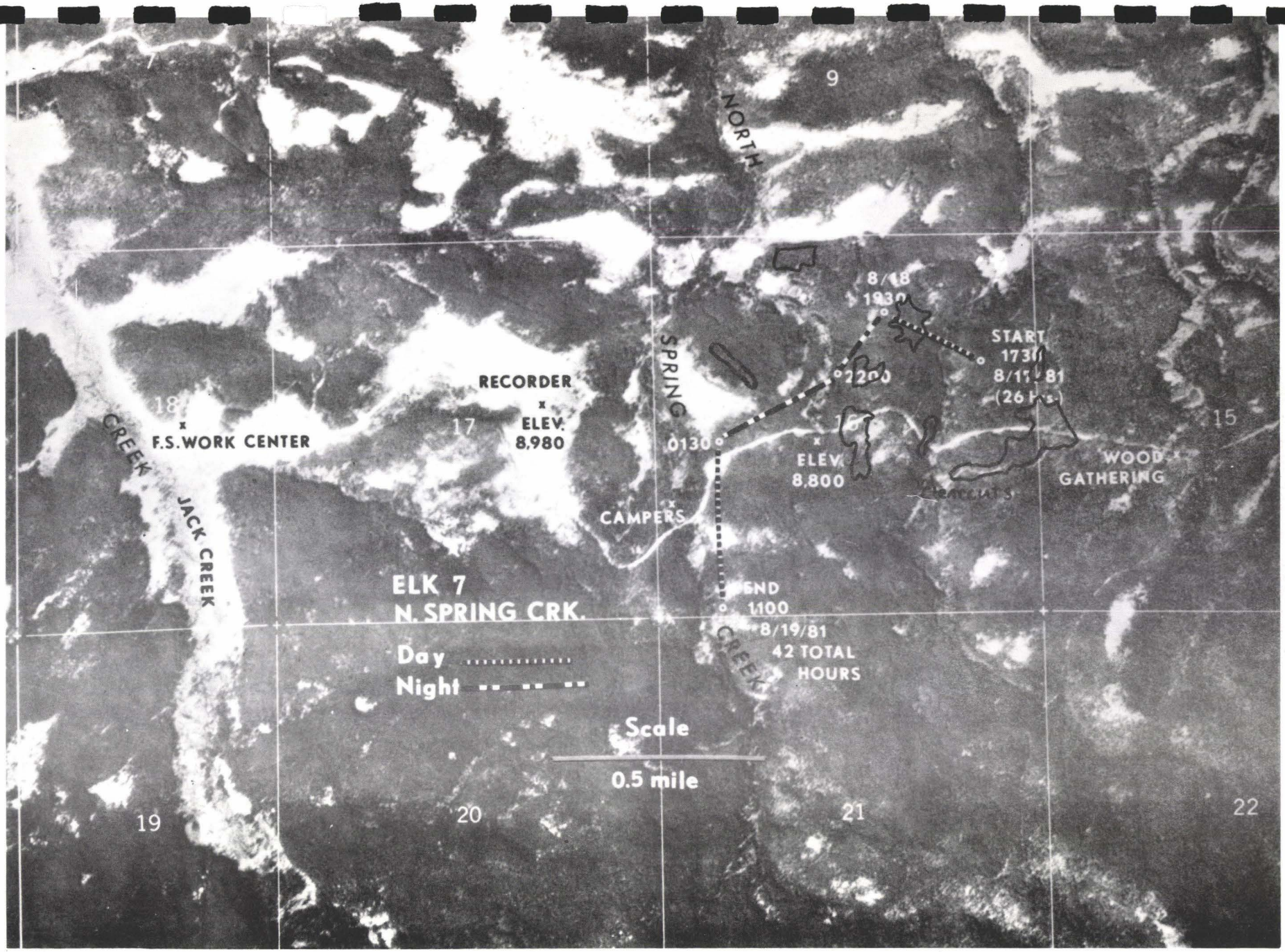

Figure 44. Cow 7 travels during August 17 to 19, 1981 in the North Fork of Spring Creek.

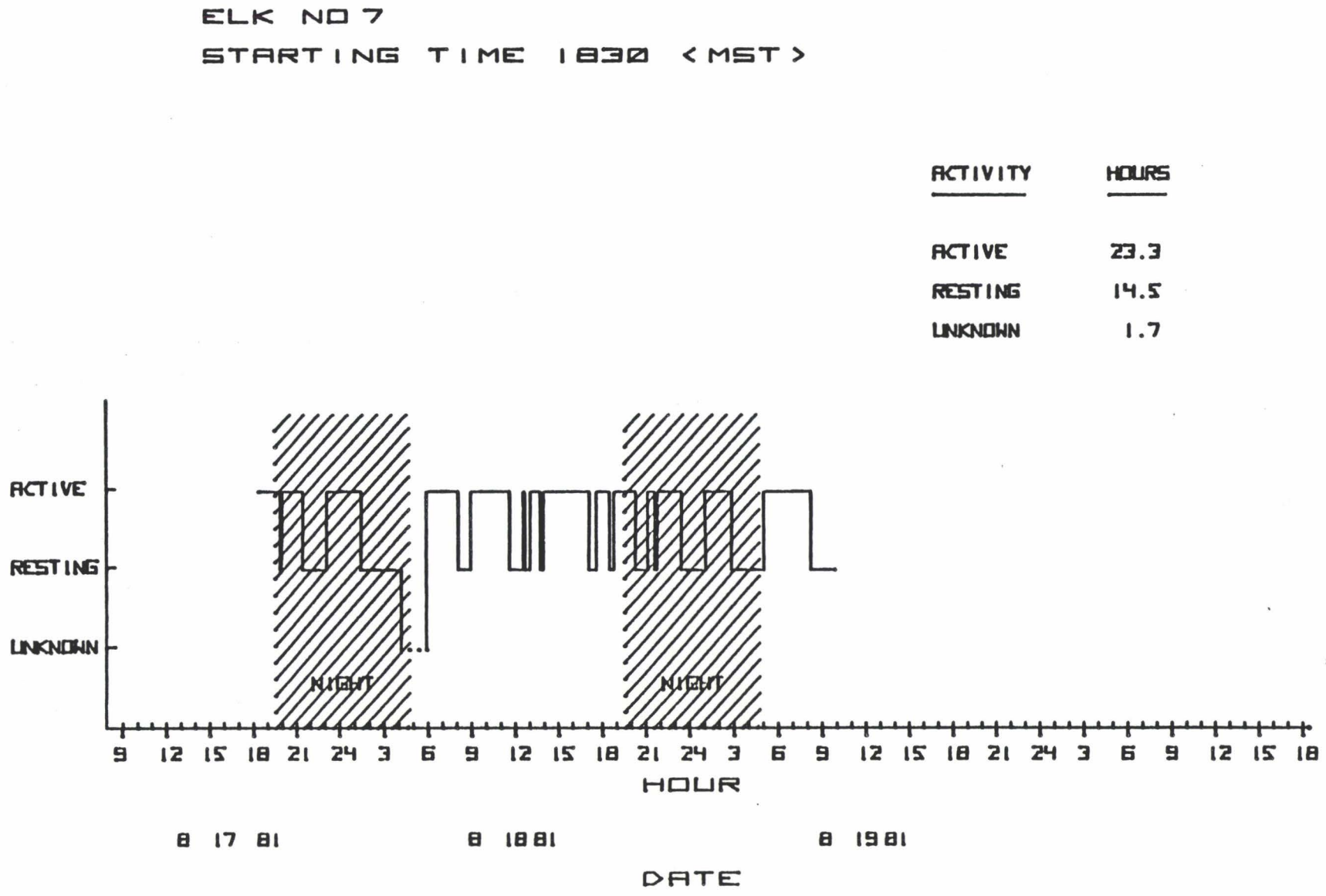

Figure 45.Cow 7 activity recorded during August 17 to 19, 1981 in north Spring Creek.

Cow 7 spent the first 26 hours in a small area of spruce-fir mixed with some aspen before she moved into lodgepole pine-aspen. A family with dogs was camped within a mile of her. The next day they gathered firewood within 0.5 mile of cow 7 and in the evening fired small arms, which did not move the elk. When she left the spruce-fir habitat at 1730, she moved toward the campers and spent the night and most of the next morning within 0.25 mile of the campers. At 0800 on August 19 the campers began shooting again, which displaced the elk at least 0.5 mile. She moved south across a graveled road, but remained within about 500 yards of the road in a lodgepole pine-aspen habitat type.

Her travels and activity for the July 27 to 30, 1982 period are shown in Figures 46 and 47. She was east of Twin Groves along the National Forest boundary at elevations between 7,800 and 8,200 feet. The vegetation there is mostly open sagebrush-grassland with scattered aspen stands and narrow strips of riparian habitat along Willow Creek. Cow 7 and her 5 to 16 associates used a 59 acre aspen-lodgepole pine-Englemann spruce patch for daytime resting. The weather was mostly cloudy with intermittent rain the first 2 days, followed by a clear sky the last day. Temperatures varied from 40° F in early mornings to around 65° F during the day. Winds were light. The moon was full, but was covered by clouds throughout most of the night.

In the evening of July 28 cow 7 and 8 cows, 3 calves, and a spike were joined by telemetered cow 34 and her associates of 3 cows, 2 calves, and a 3-point bull. Cow 34 and an unknown number of elk moved away just after midnight on the morning of July 30.

Cow 7 spent 58 percent of the 70.3 hours active both day and night. She stayed in the trees during most of the day, and fed and rested in the openings during the cooler part of the day. She and her associates stayed within 1.25 miles of county road 500 and were within 0.5 mile of the road on one occasion. She fed within 500 yards of a house trailer that was visited by its owner on July 28 at 0500.

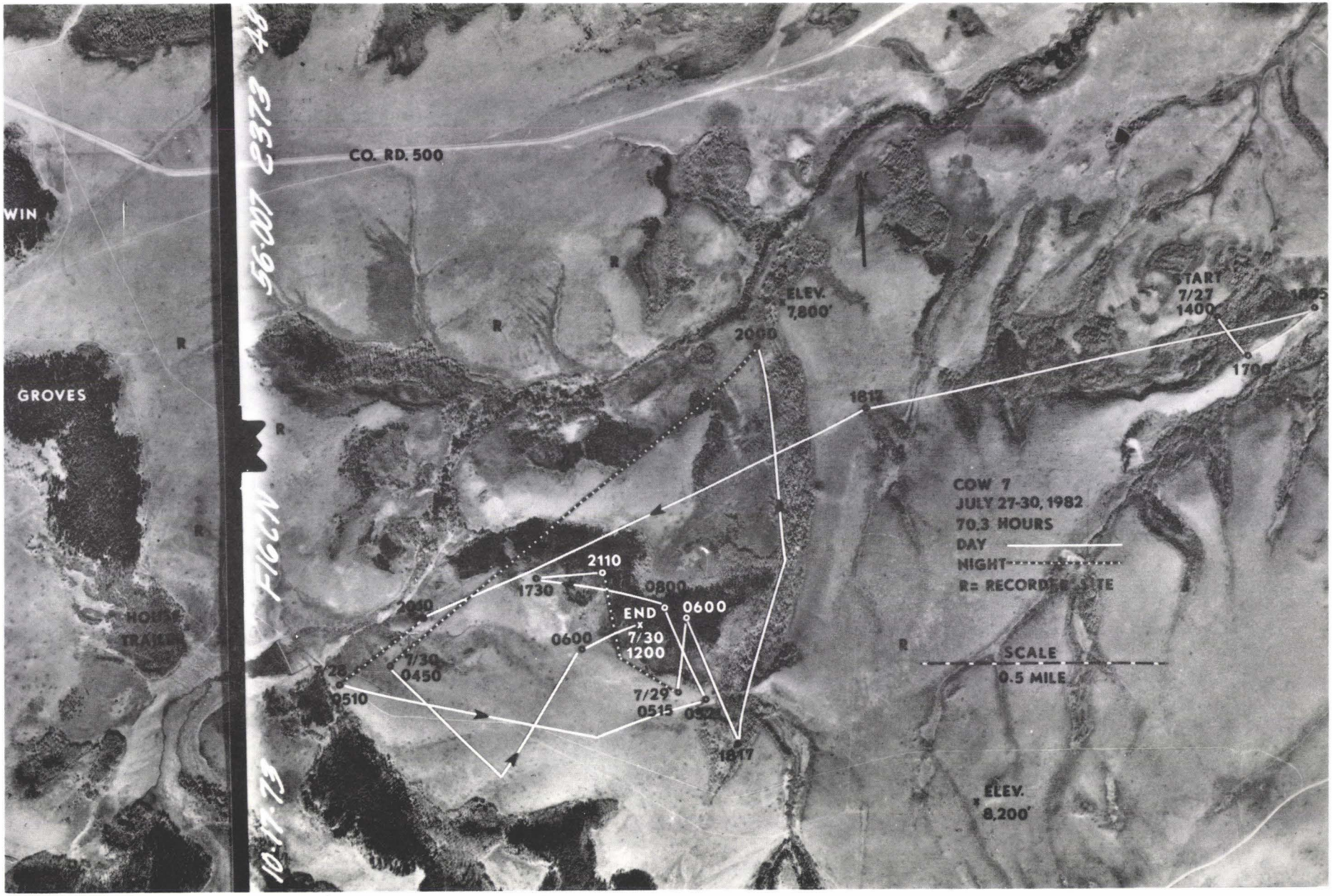

Figure 46. Cow 7 travels during July 27 to 30, 1982 east of Twin Groves.

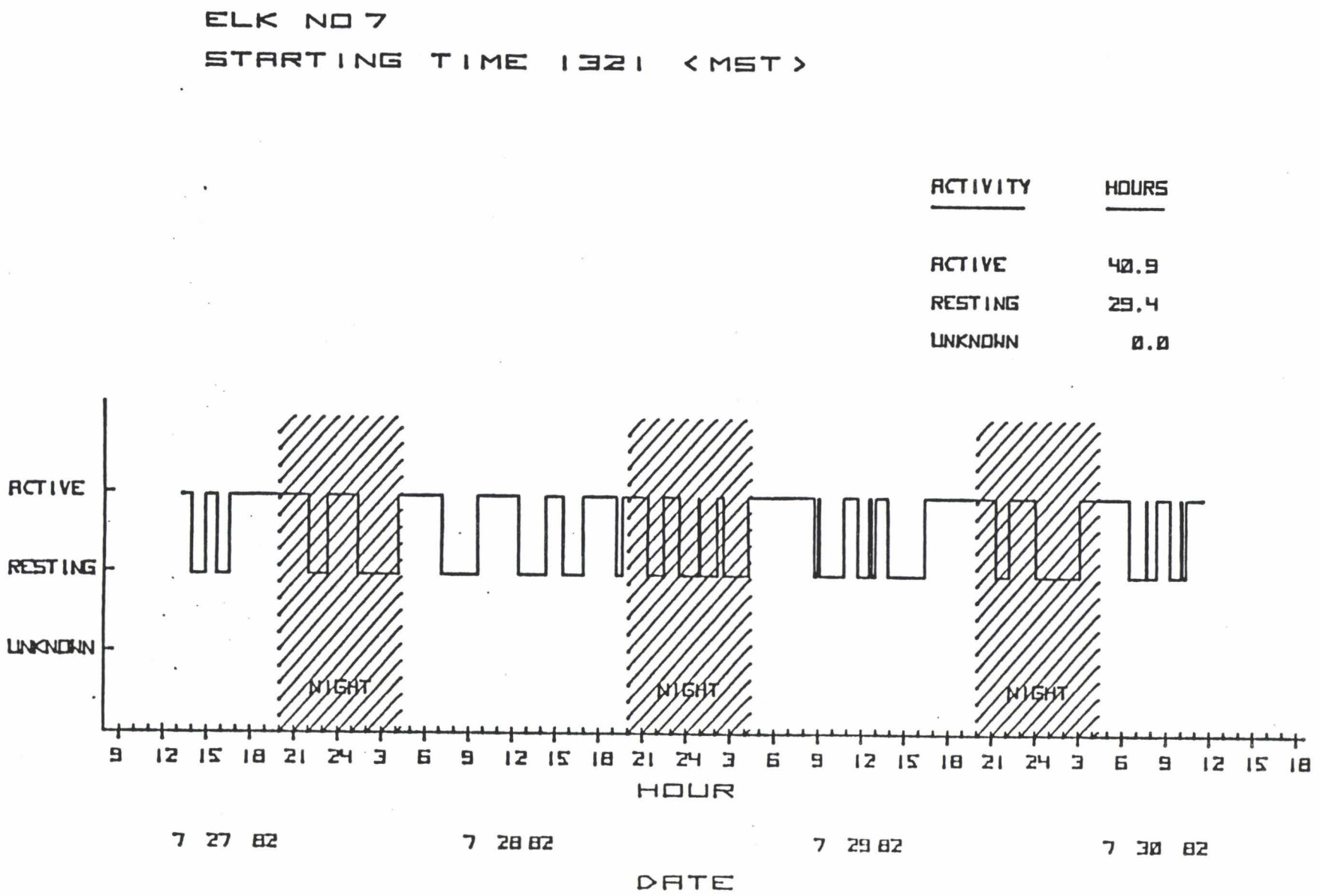

Figure 47. Cow 7 activity recorded during July 27 to 30, 1982 east of Twin Groves

Canopy cover and sight distance at 2 locations where elk spent considerable time were as follows:

Site	DBH (In.)	Basal area (Sq ft/ac)	Stems/ acre	Percent visibility 1 x 8' board 33 ft	66 ft	98 ft	Percent canopy
Aspen	4.8	194	1600	27	24	4	59
Lodgpole pine	6.2	312	1350	70	26	3	62

This area contrasts considerably to the area she used last year. There are less roads and human activity, but also a lot less timber for cover.

Cow 31

Cow 31 was a yearling calf when trapped at Divide Peak in 1981. She and other elk have occupied the summer range east of Divide Peak in Jack Creek and north of Spring Creek for 5 summers. This area has an improved road density of .92 mi/mi^2 and considerable human activity.

Cow 31's movements and activities were continuously monitored from June 14 to 17, 1982. A map of her travels and activity pattern are shown in Figure 48 and 49. She was north of the work center on the east side of Jack Creek where the elevation ranges from 8,400 to 9,000 feet and the available habitat is aspen, aspen-conifer, clearcuts, sagebrush parks and narrow riparian, in that order of abundance. There are good roads with moderate traffic throughout the area. The weather over the 72 hours was mostly cloudy with intermittent rain. Temperatures ranged from the 30's° F at night to 70's° during the day.

Cow 31 was seen feeding in a clearcut once and in sagebrush parks 3 times. She was with 3 other cows (but with no calves) in sagebrush on the morning of June 17. There were 7 other cows and a calf in another sagebrush park within 0.5 mile of her. Her resting periods were mainly in the aspen and conifer habitat, although the 7 cows and 1 calf rested in the sagebrush for a while on a cool cloudy day.

Cow 31 crossed a main graveled road twice. Two motorcycles passed along the road within 0.5 mile of the elk about noon on June 15 without causing displacement. The sound of other traffic and chainsaws within her range did not cause displacement, either. The original placement of the

Figure 48. Cow 31 movements during June 14 to 17, 1982 north of Jack Creek Work Center.

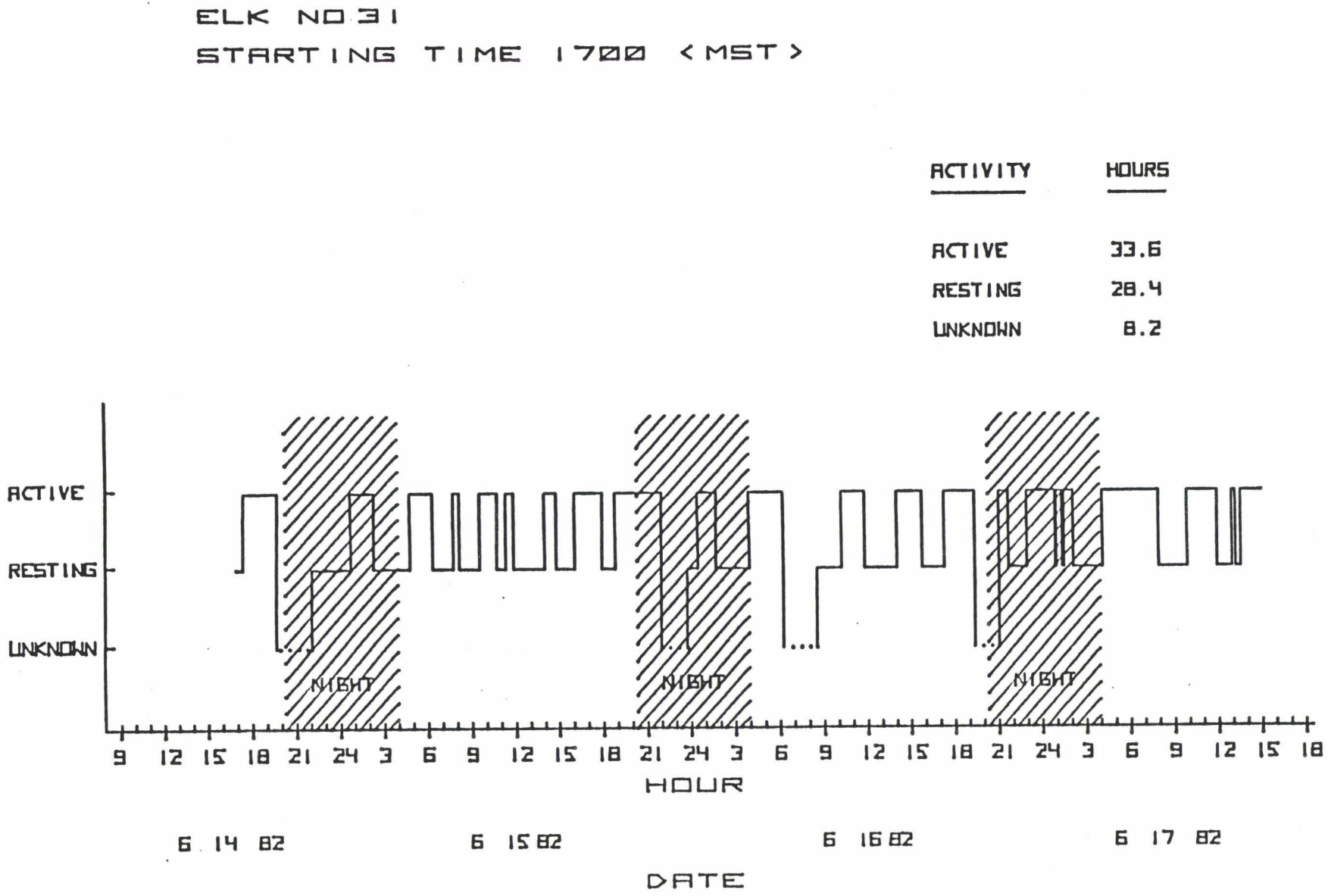

Figure 49. Cow 31 activity recorded during June 14 to 17, 1982 north of Jack Creek Guard Station.

activity monitor, within 0.5 mile of cow 31, was considered a possible disturbance. She moved about 1.5 miles on June 14, soon after the monitor was installed.

Habitat characteristics were measured at 7 sites where cow 31 and her associates spent considerable time during the day. Both these areas were considered thermal and hiding cover. However, cow 31 moved to the lodgepole pine-aspen after she was spooked on June 14.

Habitat	Tree DBH (In.)	Basal Area Sq ft/Ac	Stems/ Acre	Percent visibility 1 x 8' board 33 ft	66 ft	98 ft	Percent canopy
Lodgepole pine-aspen	3.6	278	2800	38	8	0	72
Lodgepole pine-spruce fir	6.4	240	800	60	39	19	72

The doghair stand of lodgepole pine-aspen had more trees of smaller diameter resulting in less horizontal visibility. The canopy cover was the same at the 2 sites. Cow 31 covered a mosaic of different vegetation types in about 6 square miles during the 72 hour period.

Cow 8

Cow 8 was trapped on Independence Ridge on the east side of the Continental Divide on March 21, 1984. She spent most of the summer on the south side of Blackhall Mountain. Her movements and activities were monitored from August 28 to 31, 1984. The elevations there range between 9,800 to 10,300 feet on 20 to 80 percent slopes with predominately eastern exposures. The vegetation is dominated by spruce-fir with an understory dominated by vaccinium and with intermittent openings having low-growing forbs and grasses. The weather conditions were clear to partly cloudy with temperatures in the 70's during the day and high 30's at night. Winds were mild to strong, gusting to 40-50 mph from the NW on August 31. The moon was in its final quarter, setting by 2200, so the nights were dark. Continual observation started at 1145 on August 30. Cow 8's longest activity periods were at dawn and dusk. Her movements and activity pattern are shown in Figures 50 and 51.

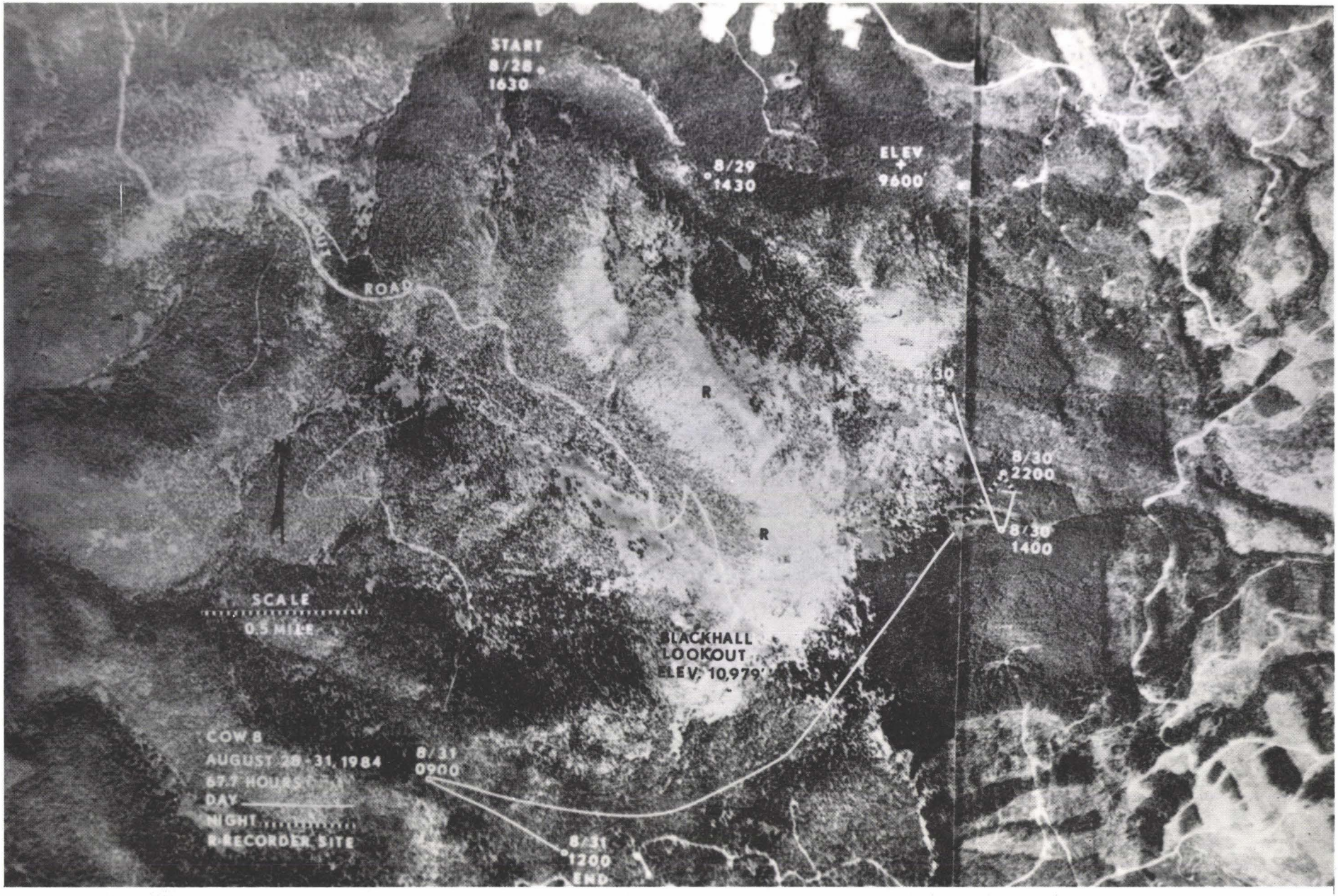

Figure 50. Cow 08 movements on the south side of Blackhall Mountain during August 28 to 31, 1984.

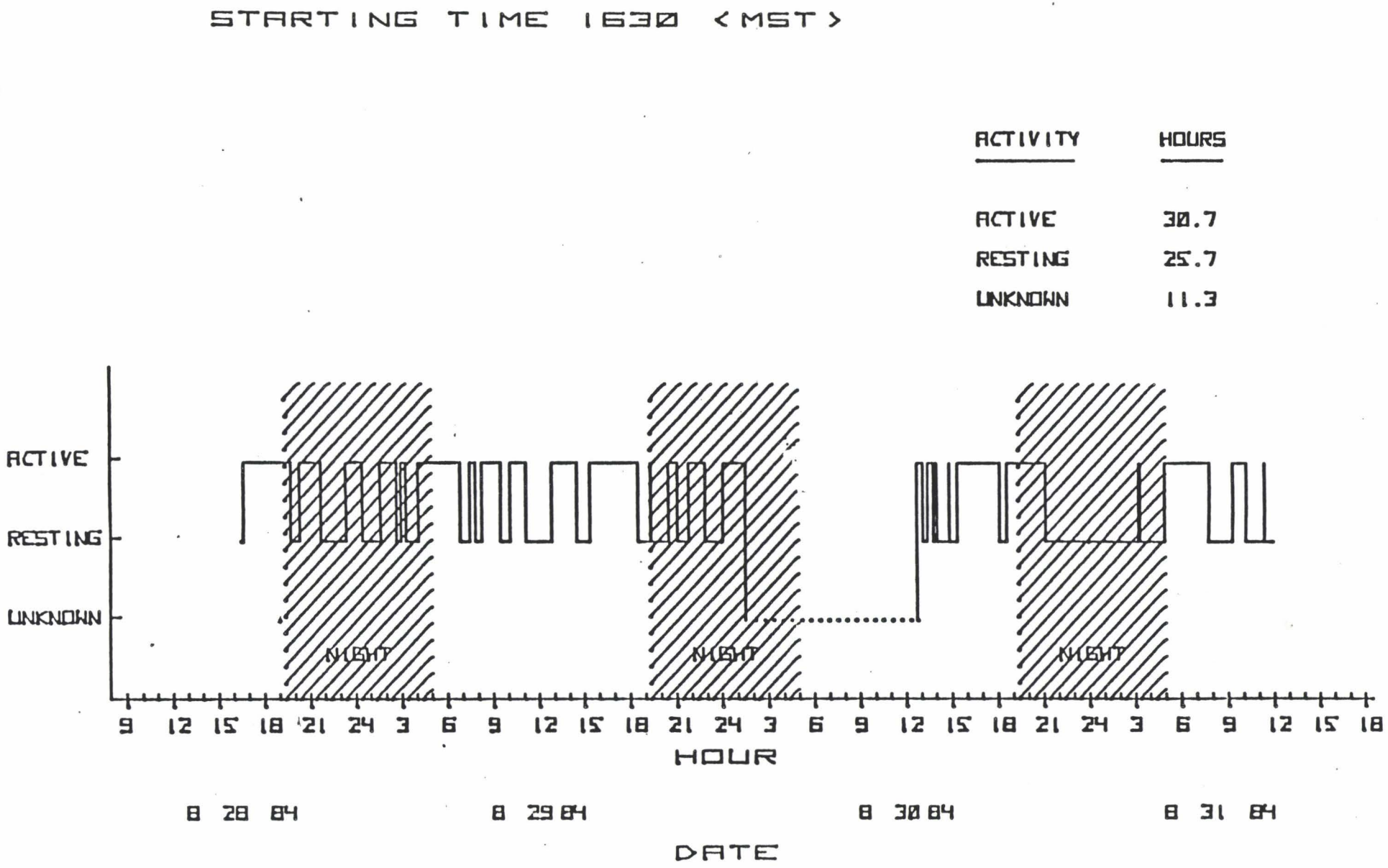

Figure 51. Cow 8 activity recorded during August 28 to 31, 1984 on the southeast side of Blackhall Mountain.

At 1405 on August 30, cow 8 became active for about 5 to 10 minutes when 2 motorcyclists made two round trips within 0.6 mi of her on the Blackhall Lookout road.

At 0930 on August 31 her group was approached on foot and were heard, but not seen. Evidence indicated 3 to 7 elk. After the disturbance the elk moved about 600 yards and rested after 52 minutes. They were disturbed again after 45 minutes, but only moved a short distance and settled down after 7 minutes. Habitat characteristics of the elk resting area at 0930 and their hiding area at 1100 were as follows:

		Avg. Tree	Basal Area	Stems/	Percent Visibility 1 x 8' board			Canopy
Activity	Habitat	DBH	Sq ft/Ac	Acre	33 ft	66 ft	98 ft	cover
Resting	Spruce-fir	3.7	166	3223	81	53	14	57
Hiding	Spruce-fir*	5.9	154	2962	79	71	27	47

*1100

Both these sites have to be considered both thermal and hiding cover although elk were not being spooked when they were initially approached. During the 56.4 hours of intense monitoring cow 8 used almost 40 acres and stayed in the 71 percent available spruce-fir habitat for 80 percent of the time. Mountain meadow habitat was also used at a rate greater than its availability, while alpine habitat was used less. Cow 8 was active 54 per cent of the time; she was active for the longest periods at dawn and dusk. The almost 6 hours of resting on the last night was unusually long.

Cow 7, 31, and 8 demonstrate the daily activity and habitat use patterns of elk on their summer range at the higher elevations within the forest. They showed a strong preference for timbered areas, particularly for resting and ruminating. Thermal and hiding cover appear to have the same horizontal visibility and canopy cover characterisitics.

Elk live in areas where improved road densities are over 1 mile per section and the habitat consists of 80 percent forest. They stay at least

0.25 mile from the traffic most of the time and at least 0.5 mile from people outside of vehicles.

Winter Range

Cow 11

This cow was a migrant elk from the south end of the KRCRA. She was trapped at Horse Mountain January 9, 1982 and was wearing ear tags from a trapping in the same location several years earlier. She spent the summer of 1982 and 1983 in the Huston Park area and winterkilled on the feedline in Colorado in February 1984. A cementum annuli examination showed her to be at least 14 years old.

Cow 11's movements and activities were monitored from March 21 to 24, 1983 while she was on the southwest side of Battle Mountain (Figure 52 and 53). Elevations there are between 7,100 and 8,100 feet and the terrain has a 20 to 60 percent slope in a southerly aspect. The vegetation is dominated by sagebrush and mountain shrub types. Snowfall of 4 to 12 inches occurred every night with intermittent snow showers during the day. Temperatures varied from 20° F in the early mornings to 45° F during the day. Most of the snow melted off the steeper south-facing slopes every day. The winds were calm and clouds hid the moon.

There is considerable interchange among elk groups on the winter range. Cow 11 was first seen with 9 other elk feeding on a bare southwest facing slope. The next morning 17 elk were in the group, which moved 0.25 mile up the slope during the night. By noon they bedded down on the southeast slope. During the heavy snowstorm on the morning of March 23 cow 11 moved down the slope of Battle Mountain and was seen feeding at 1730 with 40 elk about 0.25 mile from the county road. The last morning she was seen with 20 other elk.

Cow 11 used 133 acres during the 68.6 hours and was active 46 percent of the time. She followed the usual pattern of feeding at dawn and dusk except during the snowstorms on the morning of March 21 and 22. She also showed some activity at night.

Figure 52. Cow 11 travels during March 21 to 24, 1983 on the southwest side of Battle Mountain.

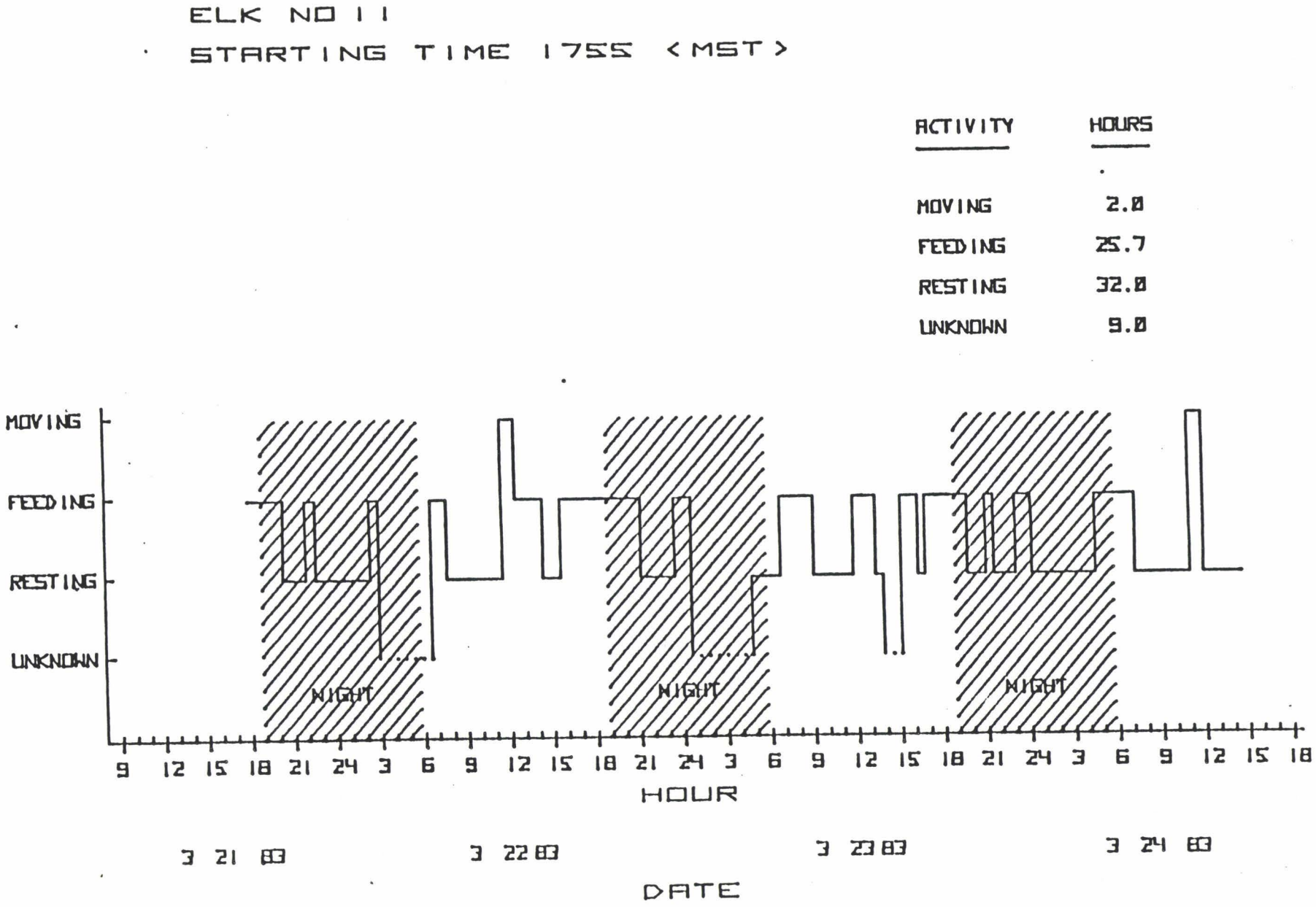

Figure 53. Cow 11 activity recorded during March 21 to 24, 1983 on the southwest side Battle Mountain.

Cow 24

This cow's movements were monitored from March 22 to 24, 1983, while she was on the south and east side of Horse Mountain (Figure 54). Elevations there range from 7,000 to 7,800 feet and the slopes vary from 10 to 100 percent. Vegetation types are sagebrush and mountain shrub. The weather was the same as for cow 11 in this period.

Cow 24 was seen with 30 elk on March 22 and by noon they were joined by 18 more elk. Later that afternoon the large group split and she stayed with 27 elk. The next day there were only 18 elk in her herd.

During the next night she and her associates moved to the south side of Horse Mountain. There were 49 elk in her group when last seen. Her travels and associations with various group sizes illustrates the typical behavior pattern of elk on this winter range.

Elk on the winter range are somewhat nomadic. They travel almost constantly and mix with various other groups. They do not show social intolerance to each other and their activity pattern is similar to other times of year, except when interupted by storms.

Elk Thermal and Hiding Cover Requirements

Available literature and opinions of managers regarding the preference of elk for thermal and hiding or security cover are still controversial. Most of the available information is associated with elk on their summer range in coniferous forest cover (see Thomas and Toweill 1980 for a review of these studies). Much of this work not only stresses the role of hiding cover on the summer range of hunted elk, but also recognizes the thermal aspects of cover.

Since elk are warm-blooded (homeothermic) they produce metabolic heat and have a heavy, low-conductance hair coat that provides efficient insulation. Under normal conditions in natural habitats they need not exert themselves excessively to maintain body temperatures. Because elk lack an extensive sweat gland system, they respond to warm weather by moving to different habitats. Some elk move to high elevations above timberline for cooler weather, others remain in shady forested areas. During very cold seasons elk adjust to the available habitat.

Figure 54. Cow 24 movements on the southeast side of Horse Mountain during March 22 to 24, 1983.

In Montana, Beall (1974) found elk selecting conifers for either thermal or hiding cover. Leege and Hickey (1977) found elk using brush fields for thermal cover during the winter in northern Idaho. On open foothill ranges in southcentral Wyoming, elk took advantage of topographic features for thermal cover when trees were unavailable (Ward et al. 1976, 1980). During cold weather elk selected areas with reduced wind-chill and/or with maximum solar radiation. During warmer winter weather they used north slopes, windswept ridges, and sometimes rested on snow drifts. Since heart rate increases with warm temperatures, it is understandable that elk seek shade during warm sunny days to conserve energy and stay cool (Ward and Cupal 1979, Lieb and Marcum 1979).

Hunted elk, wary of people, take advantage of tree cover and topography for security. In non-hunted populations of elk such as in National Parks, elk seek shade, but hiding cover is less required (Craighead et al. 1973). In southcentral Wyoming it is difficult to judge whether thermal or hiding cover is more important. Some areas and tree stands may adequately provide both thermal and hiding cover.

Other considerations which confound evaluation of cover preferences include the availability, proximity, size, and characteristics of tree stands used by elk under various circumstances, as well as the distance from and intensity of stressful conditions. Elk are very adaptable and a broad base of habitat conditions and elk requirements have to be recognized so managers can provide for elk welfare.

Thermal cover is defined for elk summer range in the Blue Mountains of Oregon as any stand of coniferous trees 40 ft or more tall with an average canopy closure exceeding 70% (Thomas et al. 1979). They estimated the optimum size of stands for elk thermal cover on summer and spring range to be 30 to 35 acres because small areas do not provide the necessary internal stand conditions to accommodate the herd behavior of elk.

Thomas et al. defined hiding cover as vegetation capable of hiding 90% of a standing adult elk from human view at a distance equal to or less than 200 ft. Circular patches of hiding cover can vary between 600 and 1,200 ft in diameter and still meet the definition of optimum habitat. This is 3 to 6 maximum sight distances. Such cover patches are from 6 to 26 ac in size.

Sight distance is a major consideration for determining security or hiding cover. Previous researchers have been concerned with how far an elk could be seen by people (Black et al. 1976, Thomas et al. 1979). I maintain that elk are not afraid of each other, so in evaluating hiding cover we should be concerned with how far elk can see their major predator "people."

Vegetation is the major cover component on elk summer ranges both because trees and shrubs hide people from view, and also because most elk require these types of habitats for thermal cover. Coniferous trees are the major species used for cover in many areas, but aspen, willows (Salix spp.), and several species of mountain shrubs can also be used very effectively. However, all materials whether they be trees, shrubs, rocks, or topographic features of the landscape should be included as cover.

Elk thermal and hiding cover characteristics were measured in each August of the study on 42 elk use sites scattered over the elk summer range. The 30 sites defined as thermal cover were selected by elk that had not been harassed by humans for at least a day. Elk moved into these sites to rest and ruminate after their early morning feeding period. These areas were considered thermal cover because the elk were using them during the warm part of the day and had no apparent reason to hide. The 12 sites defined as hiding cover were selected by elk after they were harassed by people walking and then given a chance to hide in their choice of habitat.

Aspen provided the tree cover on 20 sites. Five of those sites also had a considerable understory of mountain shrubs mixed with small aspen. All aspen stands were between 7,600 and 8,200 feet in elevation, and on 5 to 20 percent northerly-facing slopes. Aspen height varied from 11 to 40 feet. Fourteen of the sites were on the north end of the KRCRA in the Miller Hill, Atlantic and Rendle Butte areas.

Aspen mixed with lodgepole pine (Pinus contorta) made up the tree cover on 3 sites, 2 of these were identified as hiding cover. All 3 sites were at 8900 ft elevation and faced either north or northwest on 5 to 15 percent slopes. The trees were all over 20 ft high.

Lodgepole pine was the only tree species growing on 7 sites, one of which was identified as hiding cover. The other 6 are known to be used by elk during hunting seasons, but were considered thermal cover for this

study. These sites were at elevations between 8,100 and 9,300 ft on northerly-facing slopes of 2 to 50 percent. The trees were all over 20 ft high.

Two sites were in the spruce-fir lodgepole pine-aspen type at 8,800 ft elevation and on 5 to 20 percent northerly facing slopes. One was identified as hiding cover. Most of the trees were over 20 ft high.

Ten sites were in the spruce-fir type in the subalpine areas at 9,600 to 10,300 ft elevation. Two of these sites were identified as hiding cover. However, defining hiding cover in these 2 instances was difficult because the elk kept moving within the same large area when continually harassed. These 10 sites were between 5 and 80 percent in slope and faced in different directions. Some stands were predominately made up of smaller sized trees while others were a mixed size with a few very large trees scattered through the stand. Most of these trees were over 40 ft high.

The size of the tree stands used for thermal and hiding cover varied among the sites. A few of the aspen stands were as small as 5 to 10 ac at the lower elevations. Aspen at lower elevations grows only where there is adequate moisture, such as north facing slopes and the lee side of ridges.

The tree stand sizes in the coniferous areas were large and included open areas, such as clearcuts, exposed south-facing steep slopes, dry parks, and subalpine and alpine meadow areas.

The cover characteristics are summarized in Table 1. Of the 42 sites used by elk for either thermal or hiding cover, only 4 had less than 25% canopy cover. One site was in very short aspen on the north facing slope of a draw where elk were seen feeding and resting in the shade. The second site was an open lodgepole pine stand at the top of a north facing ridge where elk were laying in the shade of individual trees. The other 2 sites were in the subalpine spruce-fir type with open stands of large trees. Elk used individual trees or small clumps of trees for shade at these sites.

Aspen and aspen-lodgepole pine stands used by elk had the highest percent measured canopy cover ($\bar{X}$ = 55.7%) while spruce-fir sites had the most open canopies ($\bar{X}$ = 44.7%). The aspen-dominated sites occurred on good growing sites with northerly exposures and a fair amount of understory vegetation. These stands averaged 3.2 DBH (range 10 to 7.6 in) and 4,304 stems/ac with a range of 486 to 11,700 stems/ac. Visibility through the trees was poor to fair with 0 to 53 percent ($\bar{X}$ = 17.2%) of the board visible at 96 ft. The

Table 9. Visibility and canopy cover in known elk thermal and hiding cover used during summer.

Location	Ave. Tree In. DBH	Basal Area	Stems/ Acre	Percent of 1 x 8 ft. Board Visible 33 ft.	66 ft.	99 ft.	Percent Canopy Cover Estimated	Measured	Habitat Type
Miller Hill - north Side	1.6	80	4225	44	4	0	60		Aspen
	2.0	180	486	84	68	34	70		"
	2.6	156	5800	48	54	16	84		"
	4.2	175	2150	83	37	51	86		"
	5.1	191	2800	90	58	15	78		"
	2.5*	182	3800	69	41	22	60	63	"
Buck Springs Draw	1.8*	54	9200	28	5	0	7		"
	1.8*	74	11000	49	14	2	53	57	"
	2.8	153	6450	58	3	0	41		"
Rendel Butte	1.0	140	5000	59	33	18	31	46	"
	1.8	152	8000	30	3	0	41	39	"
	2.5	140	8000	51	28	7	37	53	"
Atlantic Rim-Jep Canyon	1.9*	96	11700	51	11	0	54	60	"
	3.0	178	900	78	45	46	58	61	"
Twin Groves	4.8	194	1600	27	24	4	59	77	"
Pole Mountain	4.3	127	970	94	46	5	25	26	"
	4.6	180	970	94	68	12	50	48	"
West of Dexter Peak	2.6	175	2500	90	73	53	51	64	"
Battle Creek - south side	1.2*	128	5400	53	19	6	44	58	Mtn. Shrub
	7.6**	186	3250	78	61	43	43	61	Aspen-Mtn.

Table 9. Visibility and canopy cover in known elk thermal and hiding cover used during summer. (Continued)

Location	Ave. Tree In. DBH	Basal Area	Stems/ Acre	Percent of 1 x 8 ft. Board Visible 33 ft.	66 ft.	99 ft.	Percent Canopy Cover Estimated	Measured	Habitat Type
Battle Mountain	4.2	203	1088	75	66	39	42	62	Aspen-lodgepole pine
	5.6*	166	900	80	69	28	48	45	" " "
Jack Creek	3.6*	278	2800	38	8	0	59	72	" " "
Twin Groves	6.2	312	1350	70	26	3	63	62	Lodgepole pine
Jack Creek	4.4	218	2000	40	57	21	33	35	" "
	4.5	199	2022	53	4	9	33	41	" "
	6.4	240	800	60	39	19	50	72	" "
Pole Mountain	4.5	149	1170	52	23	22	10	6	" "
Beaver Creek	3.3	146	3398	92	55	32	47	50	" "
Holroyd Creek	5.5*	133	1045	79	44	25	45	49	" "
Fletcher Peak	4.4	157	4704	20	38	31	69	70	Spruce-fir-aspen
Jack Creek	3.7*	217	2600	88	19	2	33	40	Spruce-fir-pine
Standard Park	42.0	242	720	92	43	27	47	46	Spruce-fir
	53.4	274	400	71	40	13	27	19	" "
Huston Park	40.4	222	720	61	39	10	31	27	" "
	52.2	164	540	81	41	16	22	29	" "
	13.5*	144	871	83	59	38	20	23	" "
	10.5	193	2788	47	37	37	33	30	" "
	3.9	164	784	62	51	28	63	63	" "
Vulcan Mountain	5.7	170	655	94	56	30	58	61	" "
Blackhall Mountain	3.7	166	3223	81	53	14	59	57	" "
	5.9*	154	2962	79	71	27	48	47	" "

*Definitely security cover
**Few large aspen with understory of shrubs.

number of stems per acre in aspen stands was negatively correlated with visibility ($r = -0.599$, $p < .02$) and basal area (-0.703, $p < 0.1$).

Sites in the lodgepole pine type had varied sight distances of 3 to 32% (X = 18.7%) of the board visible at 96 ft. The canopy cover of these sites was from 6 to 72 percent with an average of 45 percent. Stands with poor visibility were dense and even-aged. Stems per acre and DBH in these stands were negatively correlated (-0.842) as were visibility and basal area (-0.802), but these differences were not statistically significant.

The spruce-fir stands measured were predominantly open canopy (X = 40.2%) sites at higher elevations with large, older trees (X DBH = 29.8 in). The elk used a dense stand of small spruce-fir-pine trees (X DBH = 3.7 in) and and an aspen-spruce-fir stand (X DBH = 4.4 in) for hiding cover. Within the spruce-fir stands there were no significant correlations among the 5 measured parameters. Negative correlations were found between DBH and: basal areas, stems per acre, visibility, and canopy cover, though not at a statistically significant level.

Elk using the mountain shrub-aspen type moved into areas with poorer visibility for hiding cover. The difference in visibility for hiding was due to an increase in the number of small diameter stems rather than basal area. Canopy cover stayed the same for both hiding and thermal cover in the mountain shrub-aspen type.

The characteristics of thermal and hiding cover were compared with each other using 2-sample t-tests. None of the characteristics compared between thermal and hiding cover were significantly different. Average DBH and number of stems per acre had the highest levels of significance, with only $p = 0.085$ and $p = 0.104$, respectively. Average DBH was greatest in thermal cover while the number of stems per acre was highest in hiding cover. Both basal area and visibility were slightly higher in thermal cover while canopy cover was nearly equal between 2 types.

A step-wise discriminant analysis was used to further identify any timber characteristics which are significantly different between thermal and hiding cover. The number of stems per acre was the only characteristic found to be significantly different ($F = 4.809$), but the factor accounted only for 10.7 percent of the variation between the 2 cover types.

In conclusion, none of the timber stand characteristics investigated in this study can be used to distinguish thermal cover from hiding cover.

Table 10, a comparison between paired thermal and hiding cover measurements where date, habitat, and, in some cases, animals were the same, shows the overall similarities. Basal area and canopy cover were consistently greater in thermal cover, although the differences were often very small. In 4 of the 5 sites, hiding cover had a high DBH but fewer stems per acre than the thermal cover. Visibility was inconsistent with 3 sites being greater in thermal cover and 2 sites being greater in hiding cover.

Management Implications

The most reliable way to evaluate the suitability of tree stands for both thermal cover and hiding cover for hunted elk is still the on-site inspection. If that is not possible, tree size and density data from timber inventories are the next best parameters for judging the value of the cover for elk. The timber stand inventory data, however, must include all sizes of trees.

Basal area was found to be a poor parameter for judging elk cover, because a high density of small diameter stems is low in basal area while a few large diameter trees have a high basal area. A large number of small trees provides good canopy cover for shade while reducing visibility so the elk feel safe. A stand with a few large trees may have good shade under individual trees, with sight distances reduced enough for elk security.

Since we could not find a significant difference between elk thermal and hiding cover, there is no use in having 2 prescriptions as Thomas et al. (1979) proposed for the Blue Mountains of Oregon. Ideal tree stands for elk use in southcentral Wyoming have enough trees to provide shade and hide 80 percent of a pedestrian from the sight of an elk at 100 yds most of the time. During the warmest period of the year these habitat characteristics were found at elevations from 7,600 to 10,200 ft and were made up of aspen, aspen-mountain shrub, aspen-lodgepole pine, spruce-fir-pine-aspen, spruce-fir-lodgepole pine and spruce-fir. The majority of the sites had 1,000-3,400 stems/ac and an average diameter of more than 4.3 in, or were over 3,400 stems/ac with an average diameter of 1.6 in. Tree stands meeting these requirements were tall enough for elk to move under and had a

Table 10. Comparisons of thermal cover and hiding cover within the same habitats, taken on the same day.

Location	DBH	Basal Area	Stem/acre	99 Ft. Visibility	Canopy Cover
Huston Park Spruce-Fir					
Thermal	10.5	193	2788	37	30
Security	13.5	144	871	38	23
Beaver-Holroyd Cr. Lodgepole Pine					
Thermal	3.3	146	3398	32	50
Security	5.5	133	1045	25	49
Blackhall Mt. Spruce-Fir					
Thermal	3.7	166	3223	14	57
Security	5.9	154	2962	27	47
Battle Mt. Aspen-Pine					
Thermal	4.2	203	1088	39	62
Security	5.6	166	900	28	45
Atlantic Rim Aspen					
Thermal	3.0	178	900	36	61
Security	1.9	96	11,700	0	60

canopy cover between 30 and 80% ($\bar{X}$ = 49%) as measured from vertical photographs.

Various methods have been used to measure canopy cover. The photographic methods used by Clark (1961) and Bergan (1974) were similar to the method used in this study. Bergen found cover similar to this study in lodgepole pine in the same general area. The "moosehorn" described by Garrison (1949) is similar to the photograph method, but no camera is used. Lemon (1956) and Strickler (1959) describe the use of a densiometer. This instrument uses a highly polished chrome mirror with a diameter of 2 in and the curvature of a 6 in sphere. Cross-hatching and circular grids with dots are used to estimate overstory coverage.

Foresters have also developed a formula using DBH and crown width together with the number of trees per unit area to calculate a crown competition factor (CCF) (Alexander et al. 1976). CCF is used as a measure of stand density and often also used as an expression of canopy cover. Colwell (1960), Pederson et al. (1980), and Leckenby (1984) used methods to calculate canopy cover from large scale, high quality aerial photographs. It should be made clear, however, that a canopy cover estimate of 70 percent from aerial photos could be anywhere from 30 to 60 percent if viewed from an elk bed site. Possibly, this variety of methods has led wildlife researchers to conclude that elk prefer more canopy cover than we found elk using in southcentral Wyoming. With each method of measuring canopy cover there are some inherent biases that could account for differences in cover estimates.

Certainly, the 70 percent canopy cover cited by Thomas et al. (1979) and Leckenby (1984) for elk thermal cover in the Blue Mountains of Oregon, would be a problem for land managers in the central Rocky Mountains. Only the sites in thick stands of small trees produced 70 percent or more of the canopy cover recommended. It must also be pointed out that some elk in the Rocky Mountains use winter ranges that have no trees for thermal or hiding cover.

Also, both the CCF and aerial photograph measurements are known to be conducive to higher estimates of canopy cover than methods used on the ground looking up toward the sky. The size, spacing, species of trees, season of the year, and understory vegetation all have an effect on canopy cover estimates.

There is no problem in using any of the techniques as long as the manager understands the bias inherent in the technique. It would be preferable for members of all disciplines to agree on just one method and use it to construct their models and management plans.

Elk, Cattle, Sheep and Wild Horse Use of the KRCRA

There is considerable information in the literature to conclude that elk and other large herbivores share some of the same habitat and diet (Thomas and Toweill 1982). More than 35 references are listed for elk and cattle and at least 7 for domestic sheep, while several others discuss elk and other big game species. The relationship between elk and wild horses has not received much attention, mainly because there are no wild horses on most elk ranges, particularly during the spring, summer, and fall. Nevertheless, the studies conducted by Krystal et al. (1984), Hubbard and Hansen (1976), Hansen et al. (1977), Olsen and Hansen (1977), Hansen and Clark (1977), and Vavra and Sneva (1978), reported a high degree of dietary overlap between horses, cattle, mule deer, elk, and antelope during certain seasons of the year.

Wild Horses

Wild horse populations have increased in the western United States since passage of the wild Free-Roaming Horse and Burro Act of 1971. The feral horse population in Wyoming went from an estimated 4,434 in 1974 to 10,448 in 1980 (USDA-BLM and USDA-FS 1980). There is a healthy population, estimated at 190 feral horses, on the north end of the KRCRA where about 800 elk spend the winter. At least 100 feral horses were trapped from the Atlantic Rim, Miller Hill, and Red Rim area at the north end of the KRCRA during the summer of 1981. The population is slowly increasing on the southeast end of Atlantic Rim after 3 years. Horse use overlaps with elk use in the Cow Creek, Cow Butte and Deep Gulch Ridge areas.

There has been and probably will continue to be a wild horse reduction program for the area, which is needed if the 2 species are to be kept in balance with the carrying capacity of the range. Elk and wild horses are competing for both food and space on the north end of the KRCRA.

Krysl et al. (1984), using fecal analysis, reported the winter and summer diets of horses and cattle under 2 stocking levels in small pastures on the sagebrush-grass range in southcentral Wyoming. Horses and cattle consumed primarily graminoids with some shrubs and forbs. The horses ate graminoids and some browse during the winter. Needle-and-thread grass, Sandberg bluegrass, thickspike wheatgrass, Indian ricegrass, winterfat, and gray horsebrush made up most of their diet. Only traces of sagebrush were found in either horse or cattle feces.

The examination of elk fecal material collected from elk using the wild horse-inhabited area of the KRCRA shows a considerable overlap in diet, particuarly the graminoids (48.5 percent graminoids for elk) (Table 11), compared to 50 to over 85 percent reported in the literature for horses. The only exception was sagebrush. Our data shows 42.8 percent of the elk's diet is sagebrush.

Wild horses use the north end of the KRCRA all year. The horses tend to move west to lower elevations during heavy snow winters, but for normal or lighter snow winters they remain in the same general area all year. No detailed records were kept, but about the same numbers of horses were seen in the same general areas on almost every flight. Miller (1983) reported the winter range of wild horses on the Red Desert of Wyoming to be from 28 to 117 square miles. They do not appear to use this large of an area in the KRCRA.

The wild horses were seen using the same ridges and slopes used by elk during the winter. Some spatial preference was indicated, but it was not conspicuous and there was no social animosity observed. The 2 species were seen feeding within a few yards of each other on several occasions. It was difficult to tell when the horses rested because they were seldom seen laying down.

Cattle and Domestic Sheep

The proposed grazing management program for livestock on the KRCRA is presented in the Divide Grazing Draft Environmental Impact Statement 1983 from the BLM Rawlins District Office. There are 39 allotments for 42,966 animal unit months (AUM) of cattle grazing and 9 allotments for 5,249 AUMS (5 sheep/AUM) of domestic sheep grazing on the KRCRA area. The grazing seasons start either in May or June and extend to October or November.

Table 11. Elk Fecal Contents from KRCRA

	Percentages	
	North end 1981 to 1984	South end 1981 to 1983
Graminoids	60.2	49.4
Agropyron	31.0	19.7
Agrostis	0.3	
Bouteloua	0.1	0.2
Bromus	1.6	1.8
Carex	12.6	13.2
Eleocaris	0.9	
Elymus	1.8	0.3
Festuca	1.7	1.1
Hordeum		0.1
Juncus	0.8	
Koeleria	1.1	0.1
Muhlenbergia	0.4	0.4
Poa	1.6	3.2
Sitanion	2.9	0.4
Sporabolus	0.3	
Stipa	2.4	8.8
Unknown grasses	0.7	0.1
	1.2	
Forbs		
Borage		0.1
Cactus		0.1
Equisetum	0.2	0.2
Eriogonum	0.2	
Kochia	0.1	0.1
Lupinus		0.1
Penstemon	0.1	
Phlox		0.5
Vicia	0.1	
Unknown forbs	0.4	0.3
Seeds	0.2	0.1

Table 11. Elk Fecal Contents from KRCRA

	Percentages	
	North end 1981 to 1984	South end 1981 to 1983
Browse	38.6	49.1
Amelanchier	1.8	
Artemisia	30.5	28.5
Atriplex	0.2	0.5
Berberia	1.8	
Ceratoides	1.6	0.1
Cercocarpus		3.4
Chrysothamnus	0.1	1.6
Eurotia	0.3	0.1
Fragaria	0.1	
Populus	0.1	
Purshia	0.2	13.6
Rhus	0.1	0.4
Salix	0.1	
Sarcobatus	0.1	
Symphoricarpos		0.1
Tetradymia	1.6	0.3

The allotments on the north end have a checkerboard land ownership pattern. This pattern extends for 20 miles south of the Union Pacific Railroad, which covers all of Atlantic Rim and Miller Hill. Most of the land between Muddy Creek and Ketchum Butte is either BLM or state land. The land ownership pattern on the south end of the KRCRA is a mosaic of private, state, BLM and Forest Service lands. The Forest Service land is separated from other land by fencing, but the BLM, State, and private lands are not fenced separately. Most of the allotment boundaries are fenced, however. The fencing does not limit elk movements, but does control livestock.

Cattle and elk compete mainly for food on the KRCRA. There is some competition for space, but it occurs during the summer and mainly on the north end where several hundred cattle and a resident population of approximately 100 elk use the area. The elk and cattle do not appear to have social problems when they occupy the same area, but when the people come to look after the livestock the elk can be displaced. An exception was during the heavy snow winter of 1983-84. Then elk and livestock competition reached extreme proportions when deep snow forced the elk down into haystacks and feedlines along the Little Snake River.

Elk suffer the most in elk-cattle competition on the study area. Cattle use the range first, both during and after the growing season, and determine what is left for the elk during the winter. Both species show a strong preference for graminoids in their diet with lesser use of browse and forbs. Most of the forbs dry up and fracture away after maturity so they are not available for the elk in winter. Cattle do not eat much sagebrush so there is a distinct difference in browse use. The relative amounts of different plants used by both species is highly dependent upon the availability of foods in relation to production, location on slopes, distance from water, and weather conditons such as drought and snow depths.

The results of various studies have shown the differences in habitat preferences that separate these potentially competing species. Slope, exposure, position on slope, distance from water and cover, and fencing have a definite influence on how cattle and elk use an area. Cattle tend to concentrate in drainage bottoms, while elk are more active on steep slopes. Elk have more freedom of movement to feed because they have a greater ability to jump fences, climb steep slopes, and move further from water than cattle do. The extent of the actual conflict between elk and

cattle depends on the relationship of their population sizes, length of seasonal use, and the carrying capacity of the range.

One other aspect of elk-cattle relationship often considered is disturbance. Mackie (1979), Lonner (1975), and Nelson and Burnell (1976) concluded that hunted elk left the immediate vicinity when cattle were introduced on summer range. The researchers did not consider human activity in relation to cattle management, however. Ward et al. (1973) and Ward and Cupal (1979) could not detect social conflicts between cattle and elk even through monitoring elk heart rates. On winter ranges, or under other conditions of limited resource availability, little evidence of intolerance between the two species has been reported. The very close association of cattle and elk on the feedlines along the Little Snake River during the harsh winter of 1983-84 proved this point. Human activity had a more serious effect on these elk.

Competition between elk and domestic sheep, both for space and food, occurs principally on cohabited summer range because both species eat many of the same plants and because elk tend to stay away from sheep herds particularly if a herder is present (Olsen and Hansen 1977, Pickford and Reid 1943, Stever 1966, Nichols 1957, Ward 1976). Domestic sheep grazing allotments during the summer on the KRCRA overlap with several areas of winter elk range. Competition for food can become a problem particularly with browse such as sagebrush because sheep are not heavy users of graminoids and because forbs are not available to elk during the winter.

The resident elk on the north end of the KRCRA maintain the same distance from herded bands of sheep that they would maintain from pedestrians. Studies of the response of elk to other human activites indicate that elk react to the herder's activity rather than to the sheep.

Livestock numbers and length of grazing can be regulated. In recent years several grazing systems such as deferred rotation and rest rotation have been used. These systems require more fences, water development and movement of livestock. They also force better distribution of livestock grazing and more uniform use over each allotment This usually results in heavier use of the slopes. In most cases these grazing systems assure that one pasture within the system will have some standing crop available during the winter. Regrowth in the part of the allotment used earliest is responsible for this increase in available winter food.

This study did not attempt to determine the proper stocking rates for elk and domestic livestock on the KRCRA. From other data it is evident that there is some concern about present stocking. This concern is also expressed in the Divide Grazing Draft Environment Impact Statement written by the BLM Rawlins District. Under Part 1, Proposed Action and Alternatives, the selective management policy is described which involves assignment of management priorities to groups of allotments within the context of the existing planning system. Selective management is based upon the identification of allotments or areas sharing similar resource characteristics, management needs, and resource and economic potential for improvement. Allotments are identified as belonging to 1 of 3 categories: category M allotments, for which the objective is to maintain the existing situation; category I allotments, for which the objective is to correct significant problems; and category C allotments, for which the objective is to manage custodially while still protecting existing resource values. The details of the policy are contained in BLM Instruction Memorandum No. 82-292, Final Grazing Management Policy. At least 12 category I allotments are listed under either very high priority or high priority and are part of the elk winter range identified in the study. Three areas with livestock competition that are very important to elk are: The Atlantic Rim, Miller Hill, Muddy Creek and Rendle Butte areas; the Cow Creek Complex including Cow, Deep Gulch, Wild Cow, and Cherokee Creeks; and Horse and Battle Mountains.

The north side of Miller Hill and the aspen patches on Atlantic Rim, Rendle Butte, and in Buck Springs, Cabin and Horse Draws on the west side of Mudddy Creek are used by approximately 100 resident elk and periodically during the winter and spring by over 600 migrant elk. Elk welfare depends upon the food supply and aspen thermal and hiding cover. Competition between elk and livestock for both food and cover is evident. The area appears to be at capacity for both cattle and elk. If more AUM's of either elk or livestock are wanted, some change in relative numbers and/or a change in length of grazing time for livestock is needed.

The Cow Creek Complex is heavily used by elk during normal and heavy snow winters. The elk usually arrive in November or December and stay until April or May. Their use of this area was heavier in the normal snow winters of 1981-82 and 1982-83 than in 1983-84 and 1984-85 when snow was deeper. The elk use the ridge tops and southerly facing slopes for feeding

and resting. Snow accumulation areas in aspen stands on north facing slopes, on the lee sides of hills and the drainage bottoms are either not used or only lightly used by elk. Livestock competition has been difficult to evaluate because of the light use on most of the area during 3 summers. The two summers with the regular 11,515 AUM's of cattle use showed that the cattle used the elk winter range. The cattle started using steep slopes and areas over a quarter mile from water. Cook (1966) and Penchak (1983) showed that cattle moved to the steeper slopes and areas farther from water when their preferred sites in the bottoms and close to water were well used. We observed a similar situation on the KRCRA.

The situation needs more study, but it has to be done when cattle stocking is at the allowed level. No increase in the stocking rate should be considered until cattle use of the principal elk use areas is controlled. The area has been identified as a principle elk winter range with the southerly facing slopes and westerly sloping ridges being the most important elk feedings sites.

Elk winter range on Horse and Battle Mountain is very important to approximately 800 elk during normal winters. Even during the severe winter of 1983-84 the steep south facing slopes were critical winter range for about 200 elk. The part of Battle Mountain under Forest Service management is not grazed by livestock, but it is rocky and high so elk use is limited by low production and the possibility of deep snow. The rest of the area is under either BLM, State, or private ownership and livestock grazing varies with the allotment, demand for range, yearly forage production, steep slopes, and water availability. Here also, there is evidence of heavy cattle use in the bottoms especially around water. Cattle are seen on steep slopes late in the grazing season when forage is scarce in the bottoms and on gentler slopes because of the heavy use by cattle all summer. Cattle use of the uplands is greater when the weather turns cooler. The bottoms and north facing slopes do not provide much elk range during normal or heavier snow years. Elk do get some use from the steep north-facing slopes early in the winter when the snow is light and they can paw through the snow to the grass and browse.

Proper management would allow both cattle and elk to graze this area. It would require that the stocking rates for livestock be adjusted to the carrying capacity of the bottoms and terrain with less than 15 percent

slope where cattle prefer to be (Cook 1966). The rest of the area should be managed for elk and mule deer. The possibility of land trades, purchase or trade-off in livestock grazing to other areas should be investigated. The future elk management plans for the Little Snake River area depend upon the protection of this area from overgrazing by livestock and by disturbance by people. Since the elk from this area disperse to such a wide, productive, and scattered summer range, the limited amount of winter range must be recognized and maintained in good condition.

The elk using this area in winter periodically move into Colorado, their management requires cooperation between state agencies and land owners. An interagency management plan is needed, which should include a contingency plan for elk feeding during severe snow years, based on the experience in 1983-84.

Vegetation Production

Vegetation production and composition measurements were made each year during late June and early July on 36 known elk feeding sites scattered throughout the KRCRA. They are listed in Table 12. Four sites (No. 1,2,3, and 21) were on Atlantic Rim in sagebrush type habitat. Seven sites (No. 7,8,9,10,11,12, and 17) were on Miller Hill in either sagebrush or aspen (No. 10, and 12) habitat. Eighteen sites (No. 5,6,13,14,16,18,19,20, 22,23,24,25,26,27,28, 34,35, and 36) were in the Cow Creek Complex area with three of these in aspen (No. 14,18, and 19), one (No. 28) in mountain shrub and the other 14 in sagebrush habitat types. One site (No. 29) was in the sagebrush high on the north ridge of Loco Creek. Four (No. 30,31,32, and 33) were in the mountain shrub and sagebrush on the south side of Horse and Battle Mountains.

Cluster analyses made on the vegetation data from the clipped plots showed strong tendencies to divide the sites into four groups: Sagebrush-grassland; Sprayed sagebrush-grassland; Mountain shrub; and Aspen. The Sagebrush-grassland sites were further divided into four sites on Atlantic Rim, four on ridge tops in the Cow Creek Complex and the other 17 sites in the Cow Creek Complex for discussion.

All of the sites were between 6,680 and 8,200 feet elevation on slopes ranging from 2 to 49 percent and mainly in the southern to western aspect.

Table 12. Location and site characteristics of vegetation production plots.

Plot No.	Location	UTM	Feet elev.	Aspect degrees	Percent slope	Veg. type	General Location
1	Sec.23 T18N R90W	4599.8 N 290.9 E	8100	180	6	Sage	Hodorff Draw
2	Sec.14 T18N R90W	4600.6 N 292.1 E	7800	270	20	Sage	Slide Draw
3	Sec.24 T18N R90W	4599.5 N 293.0 E	8200	90	10	Sage	Top Atl. Rim
4	Sec. 4 T16N R89W	4583.7 N 298.0 E	7580	2	10	Sprayed sage	Rendle Butte
5	Sec.10 T16N R89W	4582.3 N 298.8 E	7600	280	30	Sage	Rendle Butte
6	Sec.21 T16N R89W	4580.0 N 297.0 E	8000	10	8	Sage	Rendle top
7	Sec.15 T18N R89W	4600.5 N 297.9 E	8200	270	15	Sage	Miller Hill
8	Sec.28 T18N R89W	4597.6 N 298.2 E	8200	250	6	Sage	Miller Hill
9	Sec.33 T18N R89W	4595.9 N 297.5 E	7600	100	30	Sage	Miller Hill
10	Sec.33 T18N R89W	4596.5 N 298.0 E	8000	285	20	Aspen	Miller Hill
11	Sec. 4 T17N R89W	4595.0 N 297.3 E	7600	225	12	Sage	McKinney Cr.
12	Sec.28 T18N R89W	4597.8 N 298.6 E	8000	345	6	Aspen	Miller Hill
13	Sec.17 T16N R88W	4581.7 N 306.2 E	8000	90	10	Sage	McCarty Canyon
14	Sec.17 T16N R88W	4581.8 N 306.6 E	7879	300	30	Aspen	McCarty Canyon
15	Sec.36 T17N R90W	4585.7 N 293.5 E	7500	250	12	Sage	Cow Creek
16	Sec.30 T17N R89W	4587.4 N 294.0 E	7400	90	4	Sage	Cow Creek
17	Sec.11 T18N R89W	4601.6 N 301.8 E	8100	315	15	Sage	Miller Hill
18	Sec.16 T16N R89W	4581.4 N 298.3 E	7800	90	25	Aspen	Lake Draw
19	Sec.16 T16N R89W	4581.3 N 297.9 E	7800	345	20	Aspen	Rendle Butte
20	Sec.23 T17N R90W	4589.2 N 291.6 E	7800	285	22	Sage	Buck Springs
21	Sec.34 T18N R90W	4596.4 N 289.5 E	7750	247	10	Sage	Atlantic Rim
22	Sec.36 T17N R90W	4586.6 N 292.7 E	7830	110	2	Sage	Cow Butte

Table 12. Location and site characteristics of vegetation production plots.

(Continued)

Plot No.	Location	UTM	Feet elev.	Aspect degrees	Percent slope	Veg. type	General Location
23	Sec.10 T16N R90W	4583.9 N 290.3 E	7800	202	6	Sage	Cow Butte
24	Sec.14 T16N R90W	4581.6 N 291.2 E	7760	180	9	Sage	Cow Butte
25	Sec.26 T16N R90W	4578.3 N 291.7 E	7650	180	10	Sage	Wild Cow
26	Sec.25 T16N R90W	4578.7 N 293.4 E	7600	180	25	Sage	Wild Cow
27	Sec.15 T15N R90W	4571.0 N 290.8 E	7440	225	6	Sage	Cherokee Cr.
28	Sec.23 T16N R90W	4569.5 N 290.9 E	7200	105	49	Mtn. shrub	Cherokee Cr.
29	Sec.33 T14N R89W	4557.3 N 297.6 E	7800	230	7	Sage	Loco Cr.
30	Sec.35 T13N R89W	4547.1 N 299.8 E	6680	190	9	Sprayed	Horse Mtn.
31	Sec. 1 T12N R89W	4545.5 N 301.9 E	7580	190	25	Shrub	Horse Mtn.
32	Sec. 7 T12N R89W	4544.2 N 303.4 E	7260	185	50	Shrub	Horse Mtn.
33	Sec.10 T12N R88W	4543.2 N 308.2 E	8000	195	45	Shrub	Battle Mtn.
34	Sec.24 T17N R90W	4590.3 N 292.5 E	7340	180	9	Sage	Buck Springs
35	Sec.34 T16N R90W	4575.9 N 289.9 E	7350	135	45	Sage	Wild Cow
36	Sec.28 T16N R90W	4577.5 N 289.3 E	7450	265	5	Sage	Wild Cow

Aspen sites No. 10,12,14,18, and 19 and sagebrush sites No. 5,6,7,8,9,16, and 17 were only measured in 1981 because later data on elk distribution during normal snow years showed them to be poor use sites due to accumulation of snow. Site No. 23 was not measured in 1984 because of domestic sheep use. Average total production for each of the sites is presented in Table 13.

The elk use sites on the north end of the KRCRA during normal to heavier snowfall years were almost exclusively in the sagebrush type habitat. The production was related to site characteristics, particularly aspect, slope, snow accumulation and soils. The low production sites, particularly in the sagebrush type, were associated with wind blown ridges, south facing slopes and shallow soils. The high production sites with large amounts of sagebrush were on gentle slopes with deeper soils. Both of the sprayed sagebrush sites were on gentle slopes with good soil and were sprayed at least 10 years ago.

The aspen sites were on both gentle and steep slopes with a north to east aspect and good soil. They were all associated with snow accumulation areas.

Table 13. Vegetation production on elk use sites on the KRCRA.

Habitat Type	Site No.	General Location	Years sampled	Production lbs/acre graminoides	forbs	Browse	Total
Sagebrush	1	Atlantic Rim	4	239.3	147.9	238.4	625.6
	2	Atlantic Rim	4	237.2	174.0	261.0	672.2
	3	Atlantic Rim	4	247.9	257.1	207.5	712.5
	21	Atlantic Rim	4	163.6	82.0	347.9	593.5
			Averages	222.0	165.3	263.7	651.0
Sagebrush	5	Rendle Butte	1	461.4	236.6	1018.2	1,716.2
	6	Rendle Butte	1	182.8	267.0	13.4	463.2
	7	Miller Hill	1	332.4	254.3	201.0	787.7
	8	Miller Hill	1	301.3	119.7	207.7	628.7
	9	Miller Hill	1	251.9	105.1	239.0	596.0
	11	McKinney Creek	4	296.2	181.9	207.8	685.9
	13	McCarty Canyon	1	420.7	81.4	675.9	1,178.0
	15	Cow Creek	4	328.9	292.2	243.0	864.1
	16	Cow Creek	1	178.0	115.3	119.8	413.1
	17	Miller Hill	1	236.2	350.3	773.4	1,359.9
	20	Buck Springs	3	294.3	278.7	93.3	666.3
	22	Cow Butte	3	330.9	234.3	245.4	810.6
	23	Cow Butte	2	293.3	354.5	301.0	948.8
	24	Cow Butte	3	242.1	193.7	59.0	494.8
	25	Wild Cow	3	359.6	109.3	302.5	771.4
	26	Wild Cow	3	386.6	86.2	310.6	783.4
	27	Cherokee Creek	3	276.7	155.3	169.0	601.0
	29	Loco Creek	3	386.6	124.9	163.8	675.3
	34	Buck Springs	3	256.7	193.7	59.0	509.4
	35	Wild Cow	3	423.6	533.7	349.4	1,306.7
	36	Wild Cow	3	449.8	129.1	82.1	661.0
			Averages	318.6	209.4	277.8	805.8
All sagebrush averages				303.1	202.3	275.6	781.0

Table 13. Vegetation production on elk use sites on the KRCRA. (Cont.)

Habitat Type	Site No.	General Location	Years sampled	Production lbs/acre graminoides	forbs	Browse	Total
Sprayed Sage	4	Rendle Butte	4	640.2	27.2	25.7	693.1
	30	Horse Mountain	3	572.3	25.4	88.4	686.1
			Average	606.3	26.3	57.1	689.6
Aspen	10	Miller Hill	1	466.8	199.0	106.0	771.8
	12	Miller Hill	1	118.8	519.6	51.5	689.9
	14	Miller Hill	1	514.1	103.6	408.7	1,026.4
	18	Rendle Butte	1	487.4	122.5	324.0	933.9
	19	Rendle Butte	1	387.7	314.9	131.3	833.9
			Average	395.0	255.0	204.3	851.2
Mountain Shrub	31	Horse Mountain	3	376.8	116.1	192.5	685.4
	32	Horse Mountain	3	552.0	224.5	200.7	977.2
	33	Battle Mountain	3	247.0	706.7	711.0	1,664.7
	28	Cherokee Creek	3	644.8	35.4	137.5	817.7
			Average	455.2	270.7	310.4	1,036.3

Atlantic Rim

The elk use sites on Atlantic Rim produce about equal amounts of graminoids, forbs, and browse. Production averages about 645 lbs/ac which is considered good for the type soil and exposure. Forbs are poor contributors to the elk food supply during the winter because they dry up and blow away. Elk eat the graminoids and sagebrush in about the same proportion the plants grow. The following plants contributed to over 93 percent of production:

		Percent
Graminoids:	Wheatgrasses (Agropyron spp.)	21
	Bluegrass (Poa spp.)	9
	Prairie junegrass (Koeleria cristata)	5
	Needle and thread (Stipa comata)	trace
	King spikefescue (Leucopoa kingii)	trace
Forbs:	Hoods phlox (Phlox hoodii)	7
	Rose pussytoes (Antennaria rosea)	trace
	Tufted milkvetch (Astragalus spatulatus)	3
	Fleabane daisy (Erigeron nematophyllus)	1
	Buckwheat (Eriogonum)	trace
	Stemless goldenweed (Haplopappus acaulic)	8
	Lanceleaf bluebells (Mertensia lanceolata)	1
	Larchleaf penstemon (Penstemon caespitosus)	1
	Hooker sandwort (Arenaria hookeri)	3
Browse:	Sagebrush (Artemisia spp.)	34
	Winterfat (Ceratoides lanata)	trace
	Snakeweed (Xanthocephalum sarothrae)	trace

Cow Creek Complex

The sites within the Cow Creek Complex show a considerable amount of variation in both the relative amounts of graminoids, forbs, and browse produced and the total production. The poor producing sites on ridge tops not only have low production, but the browse is very short. These sites are used heavily by both elk and wild horses during the winter. Again, the forbs do not contribute much to the winter food supply. Since horses don't eat sagebrush, they compete with elk for graminoides. The better producing sites are associated with the better soils and wetter areas. The following plants were more than 97 percent of the production:

		Percent
Graminoids	Wheatgrass (Agropyron spp.)	25
	Bluegrasses (Poa spp.)	8
	King spike fescue (Leucopoa kingii)	1
	Needle and thread (Stipa comata)	trace
	Prairie junegrass (Koeleria cristata)	5
	Sedges (Carex sp.)	1
	Bottlebrush squirreltail (Sitanion hystrix)	trace
	Indian Ricegrass (Oryzopsis hymenoides)	1
Forbs:	Twogrooved loco (Astragalus bisulcatus)	trace
	Hoods phlox	7
	Stemless goldenweed (Haplopappus acaulis)	6
	Fleabane daisy (Erigeron nematophyllus)	trace
	Flexible milkvetch (Astragalus fexuosus)	trace
	Arrowleaf balsamroot (Balsamorhiza sagittata)	3
	Flowery phlox (Phlox multiflora)	2
	Stonecrop (Sedum lanceolatum)	trace
Browse:	Sagebrush (Artemisia spp.)	36
	Winterfat (Ceratoides lanata)	trace
	Snakweed (Xanthocephalum sarothrae)	2

Sprayed sagebrush

The sprayed sagerush sites are still producing 764 lbs/ac and 86 percent of this is graminoides made up largely of wheatgrasses (Agropyron spp.) and bluegrass (Poa spp.). The sites are only fair for elk use because of snow accumulation. They also receive heavy use by cattle during the summer. The following plants are the major production:

		Percent
Graminoides:	Grasses	86
	Sedges (Carex sp.)	1
	Juncus	trace
Forbs:		3
Browse:	Sagebrush (Artemisia spp.)	3
	Antelope bitterbrush (Purshia tridentata)	5
	Snakeweed (Xanthocephalum sarothrae)	trace

Aspen

The aspen sites all had good soil and much better moisture. They were not usable during normal or heavy snow winters because of drifting. The resident elk on the north end of the KRCRA use the aspen during spring, summer and fall not only for food but also for thermal and hiding cover. Aspen sites are also used by mule deer and cattle during this same period. The following plants contribute to the major production under the aspen.

		Percent
Graminoids:	Sedge (Carex sp.)	17
	Subalpine needlegrass (Stipa columbiana)	5
	Blue bunch wheatgrass (Agropyron spicatum)	2
	Kingspike fescue (Leucopoa kingii)	5
	Idaho fescue (Festuca idahoensis)	5
	Bluegrass (Poa sp.)	5
	Rush (Juncus sp.)	2
	Nodding brome (Bromus anomalus)	5
Forbs:	Flowery phlox (Phlox multifora)	1
	Lavage (Ligusticum porteri)	12
	Milkvetch (Astragalus miser)	1
	Silvery lupine (Lupinus argenteus)	6
	Dandelion (Agoseris glauca)	1
	Northern bedstraw (Galium boreale)	4
	Western yarrow (Achillea lanulosa)	2
Browse:	Quaking aspen (Populus tremuloides)	8
	Sagebrush (Artemisia sp.)	trace
	Oregon grape (Berberis repens)	10
	Saskatoon serviceberry (Amelanchier alnifolia)	2
	Snowberry (Symphoricarpus albus)	trace
	Snakeweed (Xanthocaphalum sarothrae)	trace
	Wood Rose (Rosa woodsii)	trace

Mountain shrub

The mountain shrub habitat on the south end of the KRCRA is the major elk use area during the winter. Current (1984) gives a detailed description of the various vegetation types and communities on Battle Mountain. The mosaic of vegetation and snow distribution reflect the variation in elk use patterns. The amount of snow determines elk use areas. The deeper the snow, the more elk use the mountain shrub habitat which has a high component of bitterbrush and sagebrush. Forbs do not furnish much winter food. The Graminoids and browse make up the elk winter diet. The vegetation on Horse Mountain is similar to Battle Mountain, but with more mountain shrub and sagebrush and less aspen and serviceberry. The following plants contribute to most of the production on the elk use area:

		Percent
Graminoides	Wheatgrass (Agropyron spp.)	30
	Junegrass (Koeleria cristata)	3
	Bluegrass (Poa spp.)	3
	Needle and thread (Stipa comata)	1
	Sedges (Carex spp.)	1
Forbs:	Arrowleaf balsamroot (Balsamorhiza sagittata)	15
	Twogrooved loco (Astragalus bisulcatus)	trace
	Wood sunflower (Helianthella uniflora)	1
	Toad flax (Comandra pallida)	1
	Tapertip hawksbeard (Crepis accuminata)	trace
	Willowweed (Epilobium brachycarpum)	trace
Browse:	Antelope bitterbrush (Purshia tridentata)	13
	Sagebrush (Artemisia spp.)	10
	Snowberry (Symphoricarpus albus)	2
	Saskatoon serviceberry (Amelanchier alnifolia)	2
	Douglas rabbitbrush (Chrysothamnus nauseosus)	1
	Snakeweed (Xanthocephalum sarothrae)	2

Production on all sites varied between years. The largest differences were among the graminoids, forbs and browse rather than the totals. The amount and timing of precipitation has an effect on production. Good spring rains (5 inches in May, 1982) resulted in good production of graminoids and forbs. High winter moisture benefits deep rooted browse plants.

There was no indication that spring use by elk and mule deer had any major effect on production. The animals move off spring range as the growing season progresses; utilization cages showed no noticeable use in the area. The elk also showed a preference to move into the bottoms and north and east facing slopes during this period, which spread the utilization use out over a much larger area.

Vegetation measurements at 19 sagebrush-grass and 4 mountain shrub sites were made in the 1982, 1983, and 1984 growing seasons. Ground cover was estimated by the Daubenmire method and vegetation was clipped and oven-dried before weighing. Ten to 19 predominant graminoides, forbs, or browse species on each site were used in the regression and correlation analysis. Relative values (percentages) and absolute values (percent vs gms/sq.ft.) of cover and clipped vegetation were compared. The following regression and correlation coefficients were computed:

			Relative values			Relative values		
			Slope (B)			Slope (B)		
Year	Vegetation	N	(clip=b cover)	r	se	(clip=b cover)	r	se
1982	All	684	1.044	.95	2.6	.215	.93	.26
1983	All	720	1.058	.96	2.2	.197	.94	.26
1984	All	684	1.044	.90	3.8	.161	.87	.35
Combined								
1982-83-84	All	2088	1.049	.93	2.9	.188	.91	.30
	Graminoides	2088	0.957	.94	3.3	.166	.90	.34
	Forbs	2088	1.037	.87	2.1	.201	.90	.19
	Browse	2088	1.270	.95	3.7	.220	.91	.42

Both relative and absolute values of cover show a high correlation with clipped herbage weight. Regression coefficients are highly significant. The standard errors are low and consistent between years. Graminoids show a negative relationship between relative percentages of cover and weight, while forbs and browse are positive. Graminoids also show a smaller regression coefficient than forbs or browse.

Measuring production from estimated cover values has some advantages over clipping all sample plots on this elk range. More extensive sampling can be accomplished in the field in the same amount of time. Only a few samples need to be clipped to establish the relationship between the estimated cover and the clipped weights. No laboratory work is required on large amounts of clipped vegetation. By speeding up the process more area is covered in a shorter period of time so the production is measured without problems such as growth and utilization.

POSSIBLE RECOMMENDATIONS FOR MITIGATION AND RECLAMATION STANDARDS WHICH COULD BE USED IF COAL DEVELOPMENT PROCEEDS

The results of the five year study of elk distribution, movements, and habitat use in relation to snow distribution and planned coal resource development on the Little Snake River Known Recoverable Coal Resource Area (KRCRA) substantiated the following conclusions and recommendations for mitigation and reclamation.

Atlantic Rim

The Atlantic Rim tract is located in Carbon County, Wyoming about 15 miles southeast of Rawlins, Wyoming. The area described in the BLM "Summary of the Site-Specific Analysis and Tract Reports of Proposed Atlantic Rim Coal Tract, November 1982" is 9,373 acres of federal, private and state lands.

The projected annual disturbance would average 230 to 240 acres per year for 30 years. Surface disturbance caused by surface mining and transportation facilities would be an additional 770 acres. As many as 7,900 acres would be disturbed over the life of the surface mining operation. The livestock and wildlife grazing carrying capacity on the 7,900 acres would change due to coal development.

Background Information

1. The proposed open pit coal mining tract on Atlantic Rim is part of the crucial winter range for about 600 elk. These elk are 75 percent of all the elk using the north end of the KRCRA for winter range and 30 percent of all the elk wintering on both the north and south end of the KRCRA in Wyoming.
2. The elk use of the Atlantic Rim winter range increases with the amount of snow accumulation and severity of the winter. The tougher the winter, the more elk use Atlantic Rim, the farther north they move, and the longer they stay.

3. During normal or mild winters elk use the south half of Atlantic Rim (from Separation Creek south). They start moving off Atlantic Rim and head south in mid-March.
4. Twenty to 30 percent of the 40 to 100 elk found using the Atlantic Rim, Miller Hill, Buck Springs Draw and Rendle Butte Area are resident on Atlantic Rim. Resident elk use the small scattered aspen patches on Atlantic Rim for calving and thermal and hiding cover. When elk are displaced from Atlantic Rim by human harassment they usually move either to Miller Hill or Rendle Butte.
5. The migrant elk arrive on Atlantic Rim in December and move back toward the National Forest from mid-March to May, depending on the severity of the winter.
6. There is considerable overlap with elk, domestic livestock, and mule deer in the Atlantic Rim area. Resident elk are in competition with livestock for both food and space although the animals appear to be socially compatible. The migrant elk depend on winter food supplies left over after the summer use by domestic livestock, so although the competition is indirect, it is serious.
7. The harassment to resident and migrant elk during coal mining can be expected to displace elk as far as 2 miles during the first year or two (Ward 1985). Information from studies in Idaho (Kuck 1984) and Colorado (Johnson 1985) show that elk will make adjustments in response to the human activities associated with mining and that the area of influence can be expected to reduce to less than 0.25 mile within a few years if harassment directed at elk is controlled.
8. Fecal analysis of wintering elk shows the importance of standing crops of cured graminoids and sagebrush for elk diets. Elk graze these foods from the south-facing slopes and windswept ridges. Few elk use the bottoms or aspen during most winters because of snow accumulation.

9. If mining occurs, the elk can be expected to concentrate more use on the north end of Atlantic Rim each year. The range appeared to reach capacity during the heavy snow winter of 1983-84 and many elk spent a month in the proposed mining area before moving north, which reduced the use on the north end. Satellite photos for March 1973 and 1976 show that the area around Separation Peak receives lighter snow cover. This could explain the low vegetation production in the area and its attraction for wintering elk.

Recommended Mitigation and Reclamation

1. Since the coal mine sites are part of the crucial elk winter range, human activity should be restricted, both to one pit at a time and to the mine site, as much as possible. The transportation system should be restricted to the proposed corridors which are at least 0.25 mile from known elk use areas.
2. Elk need to get to the north end of the Atlantic Rim during severe winters. Mining activity should be confined to the west-facing slopes where people would be out-of-sight of elk moving to the north end via the east ridge. This would also minimize impacts to resident elk the rest of the year.
3. Since aspen patches are the primary thermal and hiding cover for resident elk, they should be protected from disturbance by mining. Aspen patches within a mile of the pits are particularly important for hiding cover.
4. To provide adequate food supplies for the wintering elk, the domestic livestock grazing on Atlantic Rim should be reduced on the area more than a mile from the mining sites. This will make up for the amount of food lost from areas where elk are displaced. Wild horses should be continuously controlled.
5. Livestock use can continue in the bottoms where snow accumulates, but grazing on south facing slopes and windswept ridges should be prohibited.

6. The slope, aspect, and native vegetation should be reclaimed after mining. Soil profiles and present vegetative production show that the elk use sites are poor-producing areas mainly because these areas are open in winter. Any reclamation practices to increase forage production or value on these sites, such as fertilization, top mulching with additional top soil, and possible snow control by use of contour trenching or fencing would improve the habitat for wintering elk.
7. Both permanent residence for mine workers and recreation development in the mining area should be prohibited. Dispersed recreation, particularly in the winter and spring, should be controlled on the elk use areas.
8. The elk population should be maintained at the present level until more information is obtained to determine the carrying capacity of the winter range on the north end of the Atlantic Rim.

Northeast Cow Creek Track Profile-Sandhills

The Northeast Cow Creek tract is located in Carbon County, Wyoming about 30 miles southwest of Rawlins, Wyoming. According to the BLM "Summary of the Site-specific Analysis and Tract Reports for Proposed Northeast Cow Creek Coal Tract, November, 1982," the tract would be a subsurface coal mine which has the potential to produce 1.8 million tons of coal a year for 50 years. The areas described, including federal, private, and state lands, is 8,323 acres. About 800 acres would change from livestock and wildlife grazing use to coal development.

Background Information

1. Since this tract would be mined by underground methods, the impact surface acres, both for mining and human activities, would be reduced compared to open pit mining. The possible surface facilities are located on the extreme western edge of the defined elk crucial winter range. Only during the 1982-83 winter did elk use this area; the largest number of elk seen then was 83. Many mule deer were noted using the area in 1981 and 1982, but there were no tracks seen in the heavy snow cover of 1984 and 1985.

2. Even with elk responses from human activity reaching 2 miles, the impact of the subsurface coal mining and transportation system would have minimal effects. It is agreed that the transportation route alternative A extending from Highway 789 would have less of an impact than alternative B, the extension of the railroad from Atlantic Rim.
3. No resident elk have used the proposed coal tract or sandhills during the summer and fall.
4. There are at least 50 wild horses using the south edge of the tract during the whole year. At least 180 wild horses have been counted on the elk winter range during the helicopter elk census flights.
5. Present oil and gas producing wells are tended daily and elk have been seen within a mile of this activity

Recommended Mitigation and Reclamation

1. Surface activities for the mining and transportation system should be confined to the proposed locations described in the BLM's "Summary of the Site-Specific Analysis and Tract Reports for Proposed Northeast Cow Creek Coal Tract, November 1982." Transportation route alternative A would be preferred from an elk use perspective.
2. The wild horses should be removed from the mine area and adjacent crucial elk winter range in Cow Creek, Deep Gulch, and the Wild Cow drainages.
3. Domestic livestock can continue grazing in the bottoms, but they should be discouraged from using the south facing slopes and windswept ridges that elk use in winter.
4. The present oil and gas access roads should tie into the coal mining transportation system to keep traffic concentrated and away from elk use areas as much as possible. Any permanent human settlement or recreation facilities should be discouraged.
5. Reclamation at the subsurface mine facilities should attempt to restore native vegetation.

Savery Project Preference Right Coal Lease Applications

The Savery Preference Right (coal) Lease Applications (RPLA) project is located in Wyoming and Colorado near Savery, Wyoming. The proposed coal mine consists of three areas of about 49,000 acres. These areas are covered by preference right lease applications for subsurface mining of 4 to 7 million tons of coal per year (MTY) for 46 years. Surface and mineral ownership in the project area is complex, since much of the federal coal is overlaid by privately owned surface. Surface disturbance would involve about 300 acres for the life of the project at 4 MTY and 6,255 acres at 7 MTY. The proposed surface disturbance is considered minimal, but the possible indirect impacts of human population increases are considerable.

Background Information

1. The proposed development of subsurface coal mining on the Savery (RPLA) could affect the winter range for approximately 1,000 elk. These 1,000 elk are 80 percent of the herd using the south end of the KRCRA for winter range, and 50 percent of all the elk wintering on the KRCRA in Wyoming.
2. Elk use of the Battle and Horse Mountains crucial winter range varies with the snow depth. During light snow years the elk stay higher and do not concentrate. In the heavy snow winter of 1983-84 some elk concentrated on the steep south-facing slopes, the rest moved to the feedlines along the Little Snake and Savery drainages and south into Colorado. Feeding programs by the ranchers and Colorado Division of Wildlife kept many elk from starving. The land described in the final Savery Environmental Impact Statement prepared by BLM and US Geological Survey as the Northwest and South area is part of the elk winter range used every year.
3. The majority of the elk move to higher elevations in summer. The few (30-40) elk that stay on the project area during the summer use the aspen, mountain shrub, and sagebrush habitats.
4. The steeper south-facing slopes and windswept ridges receive most of the elk feeding and resting use during the 5 to 6 month winters.

5. The proposed mining activities would not disturb the elk as much as anticipated commercial facilities, residential units, and other increases in human activities. The 400 to 800 elk using the Battle and Horse Mountains area in Wyoming during the winter would be affected, depending upon the location and occurrence of human activity. Populations of hunted elk respond to human activity by moving at least 0.5 mi (line-of-sight) from unpredictable disturbances. The elk would be disrupted on their winter range and spring migrations by the human activity.
6. Elk displaced from the winter range in Wyoming have no adjacent winter range available in Colorado that is not already fully stocked with elk. Colorado Division of Wildlife biologists confirm that their elk ranges are near capacity and increases in populations would result in long-term depletion of winter range.
7. The situation is further complicated by the interchange of elk between Wyoming and Colorado throughout the year. Approximately 300 to 500 elk that spend the summer and fall in Colorado migrate into Wyoming in the early winter. There is some movement under normal snow conditions, but more of them move back to Colorado when the snow gets deep in the Horse Mountain area.
8. There is considerable overlap of elk use with domestic livestock and mule deer use. Cattle and some domestic sheep graze the elk winter range during the summer and fall. The use of the bottoms is not considered competitive because these areas are usually covered with snow in winter. Livestock use of slopes, particularly westerly and southerly facing slopes, directly competes with elk and is considered very serious. Most of the grazing has been reduced on Forest Service lands but on Battle Mountain the BLM allotments and privately owned lands are stocked to capacity or above and no attempt is being made to control grazing on elk use areas. Deer graze with the elk, but their food habits and migration patterns are different enough to prevent serious competition.

9. The Wyoming Game and Fish Department's Strategic Plan calls for a considerable increase in the elk population to 4,200 in the Baggs herd unit over the next few years. There is potential for some increase under normal snow years if livestock use is controlled, but the results of some elk mortality and depredation problems with ranchers' haystacks during the heavy snow winter of 1983-84 justify concern, particularly on the south end of the KRCRA.

Recommended Mitigation and Reclamation

1. The increase in human activities, both residential and recreational, associated with the proposed coal mining would have direct and indirect impacts on the elk population. Some impacts could be regulated by zoning for residential areas and restricting human activities on known elk use areas. There would be some loss of winter range that could not be mitigated due to the limited availability of substitute areas. A development plan for housing, transportation systems and recreation should be made with the big game resource a prime consideration to minimize impacts.
2. More effort should be made to assure maximum available vegetation production and availability on elk feeding sites by controlling livestock use. Livestock can still use the bottoms and snow accumulation areas on north facing slopes, but they should be prevented from using the steeper hillsides and southerly-facing slopes.
3. Fencing public lands, trading off use, or outright purchase of crucial elk use areas should be investigated to erase conflicts with livestock.
4. Range improvements such as fertilization and burning should be used to increase usable forage for elk on the crucial winter range.
5. Elk from the controlled-access refuge area in Colorado that move into the Wyoming winter range need additional harvest. Public access to the public lands around Columbus, Circle, Shield, Pinney and Three Forks Mountains in Colorado should be obtained.

6. A re-evaluation of the Wyoming Game and Fish Department Strategic Plan for the elk on the KRCRA needs to be made. The winter elk population was found to be about 1,000 elk fewer than was being reported before the study. The target population increase (100% to 4,200) in the plan is too high for the available winter range without some artifical feeding program during heavy snow years. Even with the present population of elk on the south end of the KRCRA, an emergency feeding program should be established in cooperation with ranchers and the Colorado Division of Wildlife for future heavy snow years.

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